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CONTENTS

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Henry Gannett

The Society of American Foresters expresses its profound regret at the death of Henry Gannett, an Associate Member of the Society since its foundation and one of the pioneers in forest conservation in the United States.

As a geographer of wide experience and travel, he contributed largely to our knowledge of the forests of the United States and its possessions. His description and mapping of the early forest reserves led in no small degree to an accurate knowledge of the National Forests and to their proper management.

He was one of the first to study the distribution of forests with regard to climate and to investigate their effect upon rainfall.

He was instrumental in organizing the collection and analysis of forest statistics, which brought out the economic importance of the lumber industry.

As Geographer of the Conservation Commission and Editor of its report, he helped to crystallize for the first time in a comprehensive statement the existing knowledge of the natural resources of the country.

By his death the conservation movement has lost one of its earliest and most influential leaders and the profession of forestry a staunch supporter and warm friend. A man of high scientific attainments and greatly diversified activities, which were so closely interwoven with the interests of foresters, his loss will be keenly felt, not only by members of the Society of American Foresters, but by all friends of forestry.

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THE INVASION OF A PLANTED PRAIRIE GROVE

BY RAYMOND J. POOL

Contributed

The phenomena of plant migration and the struggle for the occupancy of a given substratum by similar or diverse plant species or types of vegetation offer fruitful fields for the investigator of ecological problems. Perhaps that complex phenomenon, plant succession, which often follows these two well-known tendencies and finally results in a temporary or permanent change in the vegetation of a given area contains, if not the very essence of ecology, certainly much of extreme significance. The cause and the consequences of these natural plant rotations have been subjected to thorough quantitative investigation in but few instances. The whole study of vegetative cycles is still in its infancy in so far as it concerns careful quantitative determination of environic forces and the correlation of plant associations with their forces. For instance, many scientific men of varied alliances and enviable reputations have freely expressed their views and expounded their theories (some at considerable length) with reference to the well-known treelessness of our North American prairies; but as a matter of fact these ideas, as a rule, are based upon rather meager data or flimsy and presumptive evidence. The analysis and careful interpretation of the forces which are at present operative in the maintenance of the fairly constant balance of distribution between prairies and woodlands, together with the investigation of the relations which originally prevailed here, must and, I dare prophesy, will be accomplished by students of synecology and silvics when our methods have been developed to a more nearly perfect degree than is true at present.

It is not with the thought of contributing data toward the solution of this great problem in North American biology that this brief paper was prepared, but I wish hereby merely to present some facts gathered during the last few years from a study of the invasion of a planted prairie grove that may some day have a bearing upon this important subject.

Some of the changes that have occurred during a comparatively short period of time after a prairie soil in eastern Nebraska has been planted to trees may be of interest to my colleagues in botany and forestry. There are many practical men and even some botanists who still claim that trees cannot be planted and grown successfully in a typical high prairie soil. Surely such men have never seen the trans-Missouri country, where today thousands of planted groves serve to modify and alleviate conditions that once prevailed over wide stretches of virgin treeless prairie. It has been estimated that in the single State of Nebraska 286,000 acres of trees have been planted, and by far the most of these are in typical prairie situations east of the one hundredth meridian.[1] In many places these planted groves have profoundly modified the landscape. It has even now been demonstrated that trees may be grown as a profitable planted crop[2] under those relatively rigorous and uncertain climatic and edaphic conditions characteristic of the vast stretches of sand dunes in north central Nebraska. In view of these facts, we must conclude that certain forest trees may be grown in prairie soils in abundance and with little care after they are once planted. This appears to be true throughout the greater portion of the great prairie province and under a rather variable range of soil conditions; but it also appears that these trees must be *planted.*

A fact second in importance only to the success of planted groves is that native woodlands invade our typical prairie associations not at all or at best with great slowness and uncertainty and through the medium of greatly modified and as yet mostly unknown conditions and successions. The ecotone here is usually very clearly drawn, but in some cases the transition from woodland to prairie is indefinite and gradual and the underlying forces determining forest migration are very uncertain indeed. Both the quantitative and qualitative aspects of this movement show great variations upon different exposures and gradients as well as under different climatic and floristic influences. All these points are at present under investigation in Nebraska, and it is hoped that future years' study may reveal some significant data in connection with these interesting problems that have appealed to biologists since the discovery of the prairies.

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[1] Miller, F. G., Forest Planting in Eastern Nebraska. U. S. Department of Agriculture, Forest Service, Circular 45, 1906.

[2] Smith, S. D., Forestation a Success in the Sand Hills of Nebraska. Proc. Soc. Am. For., IX, 388-395, 1914.

One of the striking features of the whole relation between the woodlands and the prairies along this extensive western battle line is the early invasion of planted groves by mesophytic and woodland plants and the almost equally early and complete subjugation of the original prairie species. Observations of this nature have been made in numerous localities throughout Nebraska, and my chief object in presenting this fragmentary paper at this time is to bring to the attention of botanists some of the more prominent changes which occur subsequent to the establishment of tree plantations in our region. These plantations must, of course, be more extensive than mere wind-breaks of two or three rows of trees, although such areas frequently exhibit prominent changes within a few years.

The grove from which I have drawn material for illustration in the following pages covers about 20 acres at present just outside the residence district of Lincoln. The situation and original edaphic and vegetational conditions were typical of what may be termed high prairie. The topography is of the characteristic "rolling" nature of the prairies of this region. The trees were started about 35 to 40 years ago by *planting* the *seeds* in furrows run at intervals of four to six feet through the native prairie sod. This method is of interest in a study of invasion, since by planting seeds instead of nursery stock practically all possibility of invasion is precluded except by means of natural phenomena. From that time until the present day no cultural methods, such as cultivation, pruning, or thinning, have been attempted. This grove, then, presents unusually excellent material with which to investigate the results of natural phenomena during the time that has elapsed since the planting of the seeds. Another feature in favor of the selection of this grove for such studies is that it has not been seriously damaged by fire, grazing animals, or other factors which frequently tend to modify considerably the normal course of development of groves in this region. Accordingly, the grove may be used to represent what unimpeded and unaided nature may accomplish under the circumstances.

The grove is in the form of a hollow square, with one side (that toward the west) lacking. The south side was planted to green ash, *Fraxinus pennsylvanica,* black walnut, *Juglans nigra,* and box-elder, *Acer negundo;* the east side to black walnut, into which have come many individuals of elm, *Ulmus fulva,* and box-elder, and the north side was planted to silver maple, *Acer saccharium.* A single row of osage orange, *Toxylon pomiferum,* was planted on the fence line just outside and parallel with the east side of the walnut portion of the grove. The grove as a whole is not in good condition at present, but the present general silvicultural condi-

tions cannot be discussed at this time. I simply wish to emphasize only some of the more prominent changes that have occurred in the composition of the undergrowth as this has been affected by the developing trees.

The plants which were dominant or conspicuous secondary members of the original population of this area were species of sod-forming prairie grasses belonging to the following genera: *Andropogon, Stipa, Panicum, Sporobolus, Kœleria,* and *Agropyron,* with such common associates as *Rosa, Psoralea, Astragalus, Amorpha, Petalostemum, Lacinaria, Phlox, Erigeron, Silphium,* and doubtless many others of a long list of the species common to the high prairies in this part of the State and largely throughout the prairie province.

At the present time, after a lapse of about 35 to 40 years, the *original sodded* conditions have *entirely* disappeared from this area. The only sodded areas in the grove at present are dominated by *Poa protensis,* which species surely has no business on a high prairie. In the open walnut grove there is a fairly continuous mesophytic sod of this nature—a very common feature of walnut plantations in the West. Not only has the prairie sod gone, but nearly every one of the original *prairie species* has also disappeared. The only plants that could in any sense be interpreted as relicts of our typical prairie flora that have been found in this grove during the last three years are *Carex pennsylvanica, Agropyron smithii, Ionoxalis violacea, Rosa pratincola,* and *Fragaria virginiana.*[3] Perhaps even some of these might be questioned as being real prairie species; however, they are usually of this nature in our locality. The infrequency and modified forms of these species are the most striking features of their presence in this plantation.

In contrast to these few infrequent relicts, witness the formidable list containing 91 species which may be regarded as invaders, or at any rate species that are only occasionally found in typical prairie-grass associations in our State. Of these 91 species about 85 per cent are distinctly mesophytic and about 60 per cent of the 91 are well-defined woodland species in this region. The woody invaders, composed of trees, shrubs, and lianas, are 24 in number, or 21 per cent of the total. The complete lists of introduced species are as follows:

TREES, SHRUBS, AND LIANAS

Catalpa speciosa (*r*)[4]
Celastrus scandens (*a*)
Celtis occidentalis (*va*)
Clematis ligusticifolia (*f*)

[3] The nomenclature throughout this paper is that of Britton and Brown's Illustrated Flora, second edition, 1913.

[4] *va* = very abundant; *a* = abundant; *f* = frequent; *i* = infrequent; *r* = rare.

Cornus asperifolia (*va*)
Grossularia missouriensis (*va*)
Juniperus virginiana (*r*)
Malus malus (*r*)
Menispermum canadense (*f*)
Morus rubra (*i*)
Parthenocissus quinquefolia (*f*)
Populus sargentii (*r*)
Padus nana (*i*)
Padus virginiana (*i*)
Prunus americana (*i*)
Rhus glabra (*f*)
Rubus occidentalis (*va*)
Sambucus canadensis (*f*)
Smilax hispida (*a*)
Symphoricarpos occidentalis (*f*)
Toxicodendron radicans (*f*)
Toxylon pomiferum (*f*)
Ulmus fulva (*a*)
Vitis vulpina (*a*)

With this number of woody plants and climbing vines which have become established in the grove in a greater or less degree of abundance we have elements which distinctly add to the woodland aspect of the plantation. In many places an underbrush composed of *Cornus, Morus, Prunus, Celtis, Grossularia, Rubus,* and *Sambucus* produces a particularly impressive aspect so common to such relatively open woods. Beneath the cover afforded by the closer stand of the relatively intolerant ash trees this undergrowth is not so dense, but nevertheless a very perfect two-storied effect is noticeable because of the abundance of small trees of *Celtis* and some of the taller shrubs. The deeper shade of the ash grove has militated against the invasion of many except the more tolerant species. The question of light appears to be very important in connection with the colonization of such groves and with the multiplication of individuals and species of invaders.

HERBACEOUS SPECIES OF DECIDEDLY MESOPHYTIC TENDENCY—MOSTLY WOODLAND FORMS

Acalypha virginica (*f*) [4]
Agastache nepetoides (*i*)
Allionia nyctaginea (*i*)
Anemone cylindrica (*i*)
Aster drummondii (*f*)
Bœhmeria cylindrica (*i*)
Botrychium virginianum (*r*)
Bromus breviaristatus (*va*)
Bromus racemosus (*va*)
Chenopodium boscianum (*f*)
Chenopodium hybridum (*f*)
Cirsium altissimum (*a*)
Elymus canadensis (*va*)
Elymus virginicus (*va*)
Erigeron pulchellus (*a*)
Eupatorium urticæfolium (*a*)
Falcata comosa (*f*)
Fragaria virginiana (*r*)
Galium aparine (*va*)
Geum canadense (*a*)
Helianthus tuberosus (*i*)
Homalocenchrus virginicus (*va*)
Ionoxalis violacea (*i*)
Lappula virginiana (*f*)
Leonurus cardiaca (*r*)
Lilium tigrinum (*r*)
Meibomia canescens (*i*)
Meibomia grandiflora (*i*)
Monarda fistulosa (*va*)
Muhlenbergia mexicana (*a*)

[4] *va* = very abundant; *a* = abundant; *f* = frequent; *i* = infrequent; *r* = rare.

Muhlenbergia racemosa (*i*)
Muhlenbergia tenuiflora (*f*)
Nepeta cataria (*f*)
Nyctelea nyctelea (*va*)
Phryma leptostachya (*r*)
Phleum pratense (*i*)
Pilea pumila (*f*)
Poa pratensis (*va*)
Poinsettia heterophylla (*f*)
Polygonatum commutatum (*i*)
Ranunculus abortivus (*i*)
Sanicula marylandica (*a*)
Scrophularia marylandica (*r*)
Solanum nigrum (*f*)
Solidago canadensis (*f*)
Solidago missouriensis (*f*)
Tiniaria scandens (*i*)
Viola eriocarpa (*i*)
Viola rafinesquii (*a*)
Xanthoxalis stricta (*f*)

The essential mesophytism of these species can hardly be questioned, while the fact that great changes have occurred in this tract is still further impressed by the observation that by far the greater number of these species are habitually associated with our typical western border woodlands. Practically every phase of the distribution of all of these species in this grove is a duplication of similar facts as they are noted in connection with our native gallery woods.

In addition to the large number of mesophytic and woodland holophytes, numerous species of fleshy and leathery fungi typical of such situations have been recorded. The occurrence of such forms as these inhabiting the rich forest floor and fallen branches helps further to magnify the indications that true woodland conditions have been developed in the grove. There are also other flowering plants that are common; but some of these may perhaps indicate that there is still a certain degree of xerophytism possessed by this habitat, although perhaps the most of these species are really more mesophytic than xerophytic. The census of our grove is completed by the addition of this list, which is as follows:

SPECIES OF VARYING HABITAT BUT FREQUENTLY MESOPHYTIC (XERO-MESOPHYTES)

Achillea millefolium (*r*) [4]
Agropyron smithii (*f*)
Ambrosia elatior (*f*)
Apocynum androasæmifolium (*r*)
Asparagus officinalis (*i*)
Capnoides aureum (*f*)
Chætochloa viridis (*f*)
Erigeron ramosus (*r*)
Lactuca ludoviciana (*a*)
Lappula texana (*i*)
Leontodon taraxacum (*f*)
Leptilon canadense (*a*)
Plantago rugelii (*i*)
Sophia pinnata (*r*)
Verbena stricta (*r*)
Verbena urticifolia (*i*)
Veronia fasciculata (*r*)

[4] *va* = very abundant; *a* = abundant; *f* = frequent; *i* = infrequent; *r* = rare.

Fig. 1.—An Area of Upland Virgin Prairie Typical of Original Conditions in Eastern Nebraska

Thousands of groves have been planted upon similar sites since 1870

Fig. 2.—An Interior View of an Upland Prairie Grove Started Thirty-five Years Ago

Note the fairly well-grown trees, and especially the rich undergrowth

With the presence of so many species that are regular members of the woodland flora of eastern Nebraska in almost their normal development, one may readily appreciate the astounding changes that have occurred within this plantation during the 35 to 40 years. I need not comment further upon the appearance of this tract and upon the individual features of the various invaders, since these features, as they are characteristic of our natural forest frontiers, are more or less well known to all botanists. About all that I need to include in this connection is the emphatic summary statement that the succession from a xerophytic grassland association to a mesophytic assemblage of woodland plants has been complete, or, in other words, that this area has been *completely transformed* from *prairie* to *forest* within the comparatively short period of 35 to 40 years. Only after a careful inspection of the above lists can you fully appreciate how striking and complete this succession has been.

But naturally the botanist is inclined to investigate the forces and other phenomena which have been operative in bringing about such a transformation of prairie into woodland, although he is at first fascinated by the necessarily antecedent study of the floristic changes involved.

The migration problem alone is interesting in connection with the disturbance of the floristic balance of many habitats or phytogeographic regions. Migration as the initial process involved in all cases of invasion reveals some striking facts in connection with the colonization of this particular grove. The nearest associations of native woods of a somewhat similar (though not so rich) composition are about three miles away, so that by far the greater number of invading species have come from at least that distance. Many plants have come into the protection of this artificially established wood by means of a number of the various well-known agents and devices for dissemination. Of the 91 species that have been found in the grove aside from the trees that were planted, approximately 25 per cent are avivectant and about 25 per cent are anemophilous. The bird-carried species include 17 or 18 trees, shrubs, and vines introduced from other groves or native woodlands in this part of the State. Twenty per cent of the invaders have taken advantage of other agents and structural devices which have enabled them to come from a distance. Numerous other species occur within the grove which are relatively immobile. The results of avian activity are especially noticeable in the presence of thickets or tangles of *Padus, Prunus, Morus, Celtis, Rubus,* and *Vitis.* Tangled growths of *Vitis, Smilax, Celastrus,* and *Menispermum* add to the woodland aspects so decisively mirrored in the presence of so many other sylvan species.

As a final problem, we might inquire as to what factors were of importance in making possible the establishment and ultimate success of the invaders. Again avoiding details, I may merely state at this time that significant differences with reference to soil moisture and organic content of the soil at various depths, light, relative humidity, and evaporation have been found to occur between the woodland area and neighboring virgin prairie. The leaf litter and humus are surprisingly abundant and deep, especially in the walnut subdivision of the grove. Probably, without doubt, changes in soil moisture, evaporation intensity, and light, as the trees developed, not only contributed most to the disappearance of the original prairie species, but also made possible the ecesis of the numerous invaders. The progress and rate of these changes, together with the determination of the plant pioneers in these changes, are at present under investigation in connection with the general study of prairie and forest successions.

From these observations we may conclude without much possibility of disproof that in this region the balance of environmental factors favors the success of trees in competition with prairie grasses after the trees are once planted in groves. The initial changes appear to be the most difficult and slow moving of all in most successional phenomena. This principle certainly holds with reference to the advance of our fringing forests. It is a matter of common observation that even in the absence of cultural methods certain tree species thrive after planting and may be expected to win out in competition with native grasslands upon the prairies of eastern Nebraska. And apparently the native sod need not necessarily be completely reduced before the trees or the seeds are placed in the soil. The balance of power, then, between the prairies and woodlands along this floral frontier is perhaps not overwhelmingly in favor of the prairie, as some have supposed, and the wonder is that our native forest areas have not extended their limits more rapidly than has been the case. Certainly very few places occur in Nebraska where within a period of 35 to 40 years the *natural* woodlands have worked such prominent changes as the above or have so completely transformed appreciable prairie areas along their borders. Some of the reasons for the slow advance of the woodlands appear to be more or less evident, but the whole succession demands extended investigation and experiment before we may possess anything like a satisfactory solution of the problem and the complete understanding of the intricate relationships existing between the eastern forest areas and the grasslands of the prairie province. The problem may be admirably attacked by means of the quantitative methods now being developed by physiologists and ecologists.

NOTES ON THE RELATION OF PLANTING METHODS TO SURVIVAL

BY E. E. CARTER

Contributed

In the spring of 1913 an experimental plantation of about one acre was established on the Harvard Forest, Petersham, Mass., for the purpose of securing data on the effects of different methods of planting. Its location is the nearly level top of a low ridge, from which the ground slopes gently to the east, south, and west. The elevation is about 1,200 feet above sea-level. The area had been used as a pasture for many years, and was covered at the time of planting with a tough sod, on which the grass had been closely cropped, and with patches of sweet fern (*Comptonia peregrina*) in the northeast and southwest corners. The use of the land as pasture had packed the upper soil, a slightly heavy gravelly loam, so hard that slits could not be made with a spade. The area is well drained, and was without shade except for the small patches of sweet fern. Trees and stands growing on other parts of the same ridge indicate that the quality of site is a medium to low II for white pine on the basis of Frothingham's yield table.[1]

On this acre five species were planted, each by three planting methods. The first of these methods is that described in the Proceedings of the Society of American Foresters, Vol. IV, p. 221 *et seq.*, which will be referred to in this discussion as the mattock-hole method, although "careful mattock-hole" method would be a better description to distinguish it from the methods in common use. The second is a slit method in which the first act is to cut off at least a square foot of sod, the second to drive the blade of the mattock as deeply as possible with one stroke, and to twist or pull the mattock so as to lift a mass of earth on the blade, thus leaving a hole into which the roots of the seedling are slipped, and the third is to remove the mattock and firm the earth over the roots by one or more vigorous stamps. For brevity this will be referred to as the "slit, sod off" method. The third method is exactly like the second except that no sod is cut off, and the seedling is left with its stem in contact with the grass. It will be referred to as the "slit, sod on" method.

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[1] White Pine under Forest Management, Dept. Agr. Bull. 13, 1914.

The species and stock used were white pine (*P. strobus*) 2–1, Scotch pine (*P. sylvestris*) 1–1, Douglas fir (*Pseudotsuga taxifolia*), Rocky Mountain variety, 2–1; Norway spruce (*Picea abies, P. excelsa*) 2–1, and western yellow pine (*P. ponderosa*), Black Hills variety, 2–1. Three of these—Scotch pine, Douglas fir, and western yellow pine—may be considered as resistant to drought and temporary drying; one, white pine, as moderately resistant, and one, Norway spruce, as tender in almost every way except in this situation to frost. The stock was all grown in the school nursery and was fair to good for its class. In planting, rows of the different species and planted by the different methods were irregularly distributed to compensate for unseen minor differences in site—as, for example, row 25, white pine, "mattock-hole" method; row 26, Douglas fir, "slit, sod on" method; row 27, Scotch pine, "slit, sod off" method, etc.

The condition of each tree in the plantation has been determined about once a month during the growing seasons, with additional inspections in late fall and spring. It now seems that the influence of the planting methods on survival cannot be traced beyond the end of the first year, and the data on this point are submitted herewith.

In any tree-planting work in which commercial conditions are approached there is sure to be some loss which appears very soon after the work is done. The roots of some trees are allowed to become too dry or are broken at some time during the change from nursery to field, or the planters have a temporary lapse from the carefulness necessary to avoid matted roots and air pockets. In short, some trees die without having started to grow in their new positions. This "planting loss" may reasonably be expected to vary with the carefulness of the planting method and with the ability of the species to recover from the shocks to which it is subjected, although the planting of trees which are functionally but not apparently dead may hide this relationship when small numbers are involved. The record of the inspection of this plantation on June 25, 1913, may serve as an example of "planting loss," for soil moisture conditions were excellent up to that date. A rainfall of 2.79 inches in April and of 3.68 inches in May had kept the ground moist enough to give every well-planted live tree an opportunity to develop in its new position:

Survival percentages at the close of the planting-loss period.

Inspection of June 25, 1913.

Planting method.	Species.					
	White pine, per cent alive.	Scotch pine, per cent alive.	D fir, per cent alive.	Norway spruce, per cent alive.	*W. Y. pine, per cent alive.	All species, per cent alive.
Mattock hole.	99.3	98.3	95.0	100.0	97.5	98.3
Slit, sod off...	97.5	93.5	97.5	94.8	97.5	96.1
Slit, sod on...	93.1	92 8	96.3	88.6	97.5	93.1

* The same number of western yellow pines planted by each method died. Several trees in each row were found to be infected with *Peridermium comptoniæ* and were destroyed at the close of the "planting loss" period, but are not included in this computation.

It is necessary to go to the figures for all species combined, which apply to over 1,500 trees, to draw conclusions of the effect of the planting methods at this stage. The loss of 1.7 per cent of the trees planted by the mattock-hole method represents chiefly trees really dead, but still green at the time of planting. This loss is more than doubled (3.9 per cent) in the "slit, sod off" method and is quadrupled (6.9 per cent) with the "slit, sod on" method. These increases are unquestionably due to the unnatural position of the roots and the presence of air pockets in the cases of both the slit methods, and, when the sod is not removed, to planting at the wrong depths as a result of the grass hindering a clear view of the seedlings when they are put in place. The heavy loss in the case of the spruce—notoriously tender to too deep or too shallow planting—was evidently due largely to this latter fault, which seems inherent in the method, but may be lessened as planters gain experience or by close supervision. Even so, it is surprising that the relative losses between the two slit methods should be as great as 1 to 1.77. The presence of the sod must have greatly hindered the packing of the earth about the roots of the trees to give a "planting loss" of 2.5 per cent with the white pine put in by the "slit, sod off" method and of 6.9 per cent when stock from the same lot was planted on the same site by the "slit, sod on" method.

The hardier species, as a group, show less variation in the results by the different methods than do the more tender. The Douglas fir even had a slightly larger loss in the "mattock-hole" rows than in those planted by the slit methods. This is an abnormality similar to the 100 per cent survival in the "mattock-hole" planted Norway spruce. No great importance can be attached to the behavior of any one species at this stage of the experiment.

In a season of normal or excessive rainfall the "planting loss" would account for most of the first-year deaths in such a plantation as this. The growing season of 1913, however, was deficient in precipitation, and what rain did fall was chiefly in brief, severe thunder-storms, followed by warm, drying weather. The deficit in rainfall for New England as a whole is given by the Weather Bureau as 4.11 inches for the months of June, July, and August. In Petersham, June passed with a total precipitation of .89 inch, and while July had 2.44 inches of rain, all but .59 inch of this fell in the last four days of the month and came in pelting thunder-storms. The first three weeks of August were also abnormally dry. The effect of this drought is evident when the record of this plantation is examined. Losses, which can be attributed only to lack of moisture at the season of greatest transpiration, occurred for all species and methods under discussion. The progress of these losses may be followed in Table II, but it is sufficient here to consider the record of the inspection of September 29, 1913. The September inspection is taken rather than that of August because trees were not classed as dead so long as they had any appearance of life, and many trees were so weakened by the summer drought that they died in September, although classed as alive but weak in August. The western yellow pine is omitted, for the losses from *Peridermium comptoniæ* had been so heavy as to render worthless survival data with reference to any other cause of loss. The small number of this species makes the comparison of the results for all species still possible.

Survival percentages at the close of the summer drought period.

Inspection of September 29, 1913.

Planting method.	Species.					
	White pine.		Scotch pine.		Douglas fir.	
	Per cent alive.	Loss since 6/25, per ct.	Per cent alive.	Loss since 6/25, per ct.	Per cent. alive.	Loss since 6 25, per ct.
Mattock hole	96.7	2.6	91.2	7.1	86.2	8.8
Slit, sod off.......	83.5	15.0	90.2	3.3	82.7	14.8
Slit, sod on.......	65.1	28.0	80.7	12.1	81.5*	14.8

* In this case the effect of the drought did not end with the September inspection. On November 18 it was found that a further loss of 3.7 per cent had occurred, chiefly in trees classed as weak in September, thus leaving a survival percentage of 77.8 at the end of the first year.

Survival percentages at the close of the summer drought period—Continued

Planting method.	Species.			
	Norway spruce		All species.	
	Per cent alive.	Loss since 6/25, per cent.	Per cent alive.	Loss since 6/25, per cent.
Mattock hole	82.9	17.1	90.7	7.6
Slit, sod off	67.5	27.8	82.5	13.6
Slit, sod on	42.0	46.6	69.7	23.4

The data for all species combined do not show quite the same proportion between the losses by the three planting methods during this drought period as in the "planting-loss" period. Instead of 1 to 2.3 for the ratio of loss between the "mattock-hole" and the "slit, sod off" methods it is 1 to 1.8, and instead of 1 to 4.06 between the "mattock-hole" and the "slit, sod off" methods it is 1 to 3.08. Between the two slit methods, the ratio of loss is 1 to 1.72 for the "drought period" instead of 1 to 1.77 for the "planting-loss" period. This lowering of the ratios is due chiefly to the behavior of the Scotch pine and Douglas fir planted by the slit methods, for these species showed a remarkable ability to survive the drought, whether considered from the viewpoint of the ratios of losses by planting methods or of the percentage of actual survival. Another factor tending to reduce the ratios was the deaths during the "planting-loss" period of some of the weaker trees planted by the slit methods, when strong trees no better planted managed to live and even to endure the drought, whereas in the "mattock-hole" rows some of the naturally weaker trees withstood the shocks of planting, but could not survive the drought. This is indicated by the ratios of the percentages of loss at the ends of the periods for each method:

Planting method.	Loss 6/25. Percentage.	Loss 9/29. Percentage.	Ratio of losses.
Mattock hole	1.7	9.3	1 to 5.5
Slit, sod off	3.9	17.5	1 to 4.5
Slit, sod on	6.9	31.3	1 to 4.5

The strong influence on survival of cutting off the sod before planting by the slit method deserves further mention. That it should continue to be so strong after the first effects of the planting had shown themselves was a surprise. In spite of the drought the percentage of survival for trees planted by this method is sufficient (over 80 per cent) to give a

fairly satisfactory stand for all the species except the very tender spruce. A few of the trees that did die were killed by sods which were not completely cut off and which the wind, after they had dried out, blew back onto the trees, as a leaf in a book is turned. This minor source of loss is easily guarded against, once known.

A repetition of the experiment on a larger scale would probably reduce the irregularities in the survival data within and between species. The surprisingly small loss in the white pine planted by the "mattock-hole" method is in accordance with the results in other plantations established in 1913. Its cause may be that, of the species planted, the white pine alone is thoroughly at home in the soil and climate of Petersham, and so it may be able to respond to careful treatment better than the exotics. It is also possible that the location of the rows was exceptionally favorable, since three out of four were in the north half of the area. However, the Scotch pine "mattock-hole" rows were close to these white-pine rows and they show a disappointing loss, both relatively to the results by other methods and in comparison with the white pine.

The slit methods gave the expected poorer results with the white pine than with the resistant Scotch pine. If the data from this plantation are at all indicative, however, white pine planted by the "slit, sod off" method should give satisfactory survival results except where there is a combination of wide spacing and a very exceptional drought. Survival results from the "slit, sod on" method cannot, however, be expected to be satisfactory if weather conditions approach those of 1913 in Massachusetts, although they should be acceptable in a season like 1914 (see Table I). A total loss of 35 per cent in the first year is too large to secure good quality of product if close spacing has been tried, or will almost inevitably leave some large gaps in the crown cover if the spacing has been wide. Doubling the loss at the end of the first year by leaving the sod is a heavy handicap for the method compared with cutting the sod off.

There was very little winter loss in this plantation. In the summer of 1914 the rainfall was not greatly in excess of that of the previous year, but was well distributed and came chiefly from prolonged cyclonic storms rather than from short thunder-storms. The rain soaked well into the ground instead of being quickly subject to evaporation by drying winds and hot sunshine. It was not until the second fall after planting, when growth for the year had practically ceased, that the trees were tested by another severe drought. This fall drought was caused by a lack of precipitation even more striking than occurred in 1913, for the total rainfall from August 30 to October 15 was only .29 inch. The critical months had passed, however, and no losses attributable to deficient moisture ap-

peared in this plantation. In fact, the influence of the planting methods cannot be traced satisfactorily in the second year's record, for such losses as did occur were small in extent and were due chiefly to trespassing cattle (which broke several white pines), to ants and other insects, to rabbits, and, in the case of one tree, to a chipmunk. The loss in the western yellow pine from *Peridermium comptoniæ* continued.

Attempts were made, on a small scale, to determine the behavior of stock larger than that commonly used in planting in New England. One row (about 40 trees) each of white pine 2–1–1, "mattock-hole" method; Scotch pine 1–1–1, "mattock-hole" method, and Scotch pine 1–1–1, "slit, sod off" method were planted in 1913, and two rows of Douglas fir 2–1–1 were planted by each method in 1914. The results of the use of large stock in 1913 are striking in one way—there was no loss from summer drought, although one Scotch pine was so weakened that it died in 1914. The "planting loss" was one white pine out of 41 and one Scotch pine, "slit, sod off" method, out of 37, with one other tree in the same row destroyed because of infection with Peridermium. The Douglas fir planted in 1914 gave no results worth considering, because of the well-distributed rainfall and because most of the trees were planted in the shade of a fairly dense cover of sweet fern. The losses in this large stock of a hardy species were insignificant, irrespective of planting method.

Differences in the growth of the trees planted by the three methods are already discernible. Without going into the details, it may be of interest that of the white pine 2–1 stock still alive, 88 per cent of the "mattock-hole" planted trees are making good growth, compared with 80 per cent of those planted by the "slit, sod off" method and 76.5 per cent of those planted by the "slit, sod on" method. This relation is in spite of the elimination by death of most of the smaller trees planted by the more severe methods. It is hoped to continue the record of this plantation for some years to follow these variations in growth carefully.

No attempt will be made to compare results in relation to costs by the three planting methods, since costs vary with location, with the intensity of supervision, and with the quality of the labor available, and since survival alone should not be taken as determining results. The "mattock-hole" method is, as a rule, prohibitively expensive for commercial plantations. Often the planter has to use a cheaper method and pray earnestly for rain. By taking the survival results by the "mattock-hole" method as a standard, however, the effect of using cheaper methods may be measured, both for "planting loss" and for any drought losses that may occur.

Table I.—*Precipitation record, Petersham, Mass.*

Month.	1913. Rainfall, inches.	1914. Rainfall, inches.	[1] Normal. Rainfall, inches.
January	....	2.30	3.54
February	....	4.57	3.97
March	....	3.71	3.90
April	2.79	4.05	3.01
May	3.68	2.62	3.66
June	.89	2.05	3.18
July	[2] 2.44	2.07	4.25
August	3.16	3.43	4.16
September	2.22	.29	3.44
October	5.50	1.52	3.76
November	1.54	2.25	4.54
December	3.04	2.06	3.40

[1] Assumed. Average of normals for Amherst, 20 miles west, 24-year record; Fitchburg, 25 miles east, 30-year record, and Worcester, 30 miles southeast, 21-year record.

[2] Of this, 1.85 inches fell on the 28th and 29th. The rainfall from June 22 to July 27 was .59 inch, with only one shower yielding over .15 inch (.27 inch on July 12).

TABLE II.—PLANTATION INSPECTION RECORD

Species and planting method	Dates of inspection 6/25/13 % alive	7/21/13 % alive	8/23/13 % alive	9/29/13 % alive	11/18/13 % alive	5/1/14 % alive	6/22/14 % alive	7/28/14 % alive	8/28/14 % alive	10/3/14 % alive	11/16/14 % alive	Number of trees planted
White pine 2–1:												
Mattock hole.........	99.3	99.3	96.7	96.7	96.7	96.7	93.4	93.4	92.1	92.1	[1] 92.1	153
Slit, sod off..........	97.5	92.4	84.2	83.5	83.5	82.3	81.6	81.6	80.3	80.3	79.7	158
Slit, sod on...........	93.1	77.7	68.0	65.1	64.6	64.0	64.0	63.4	63.4	63.4	62.8	175
Scotch pine 1–1:												
Mattock hole.........	98.3	94.4	93.6	91.2	91.2	91.2	91.2	91.2	91.2	91.2	91.2	125
Slit, sod off..........	93.5	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	90.2	124
Slit, sod on...........	92.8	85.5	81.6	80.7	80.2	80.2	79.6	79.6	79.6	79.6	79.6	207
Douglas fir 2–1:												
Mattock hole.........	95.0	91.2	88.7	86.2	86.2	85.0	85.0	85.0	85.0	85.0	85.0	80
Slit, sod off..........	97.5	91.4	86.4	82.7	82.7	82.7	81.4	81.4	81.4	81.4	81.4	81
Slit, sod on...........	96.3	92.6	82.7	81.5	77.8	76.5	75.3	75.3	74.1	74.1	74.1	81
Norway spruce 2–1:												
Mattock hole.........	100	93.9	82.9	82.9	82.9	81.7	78.0	78.0	78.0	78.0	78.0	82
Slit, sod off..........	94.8	88.3	70.1	67.5	67.5	67.5	66.2	66.2	66.2	66.2	66.2	77
Slit, sod on...........	88.6	67.0	46.6	42.0	42.0	42.0	42.0	40.9	40.9	40.9	40.9	88
Western yellow pine 2–1:												
Mattock hole.........	97.5	Irregularly distributed losses from *Peridermium comptoniæ* make								....	....	40
Silt, sod off..........	97.5	the record valueless after 6/25/13				....	....	....	....	....	....	40
Silt, sod on...........	97.5	....	....	....	....	....	....	....	....	....	....	40
White pine 2–1–1:												
Mattock hole.........	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	41
Scotch pine 1–1–1:												
Mattock hole.........	100	100	100	100	100	100	100	100	97.4	94.9	94.9	39
Silt, sod off..........	[2] 94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5	94.5	37

[1] The relatively heavy second-year loss in the "mattock hole" planted white pine was caused chiefly by trespassing cattle.
[2] Half of the loss was due to infection with *Peridermium comptoniæ*.

A FORMULA FOR NORMAL GROWING STOCK IN SELECTION SYSTEM FORESTS

BY THORNTON T. MUNGER

Contributed

In preparing a working plan recently for a western yellow-pine forest, which is to be managed by the selection system, I needed to ascertain the amount of the normal growing stock in order to apply the Austrian formula and arrive at the proper annual cutting allowance.

In the literature on forest management I could find no formula which seemed to be applicable for securing the normal growing stock in a case of this kind, and I finally decided to use the formula herein described. I am calling it to the attention of readers of the Proceedings, for it is so simple that it is thoroughly applicable in preparing preliminary working plans for our virgin forests where adequate yield tables cannot be prepared. I submitted it for criticism to Prof. H. H. Chapman, who, I found, had already used it in his lectures, and a part of his valued comments I quote later.

In the forest under consideration the present overstocked virgin stand (the real growing stock) averages about 16,000 board feet per acre; the selection cutting removes about 12,000 feet; so that each coupe, after cutting, contains some 4,000 feet per acre of merchantable timber. Current growth studies show the annual increment following such a selection cutting to be about 100 board feet.

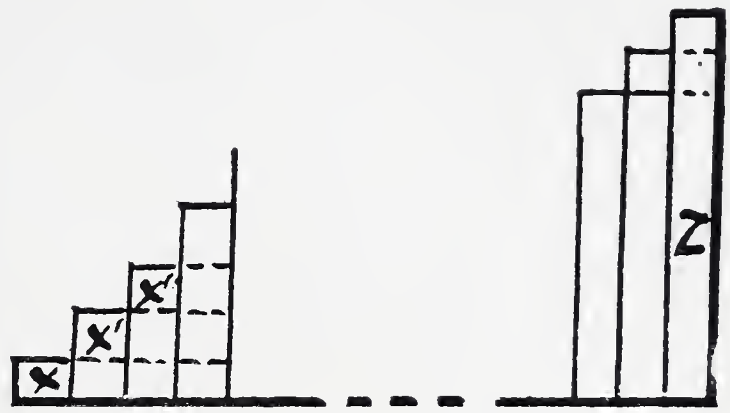
It is the present plan to manage this forest on about a 200-year rotation, with a cutting cycle of 50 years; hence one-fiftieth of the forest will be cut over each year, immediately after which cutting each coupe will contain 4,000 board feet, to which will be added annually by growth 100 board feet per acre. At the end of the cutting cycle each coupe, when ready for cutting, will contain its original 4,000 board feet plus the 50 years of increment ($50 \times 100 = 5{,}000$), or a total of 9,000 feet. The stand on this short rotation will probably not contain the large quantity that the overstocked 300 or 400 year old virgin forest did. To arrive at the normal growing stock of a forest such as this, the formula for even-aged stands is manifestly not applicable—that is, $Gn = \frac{I \times R}{2}$, when

Gn = Normal growing stock.

I = Annual increment of whole forest (annual increment of each coupe $\times$ rotation).

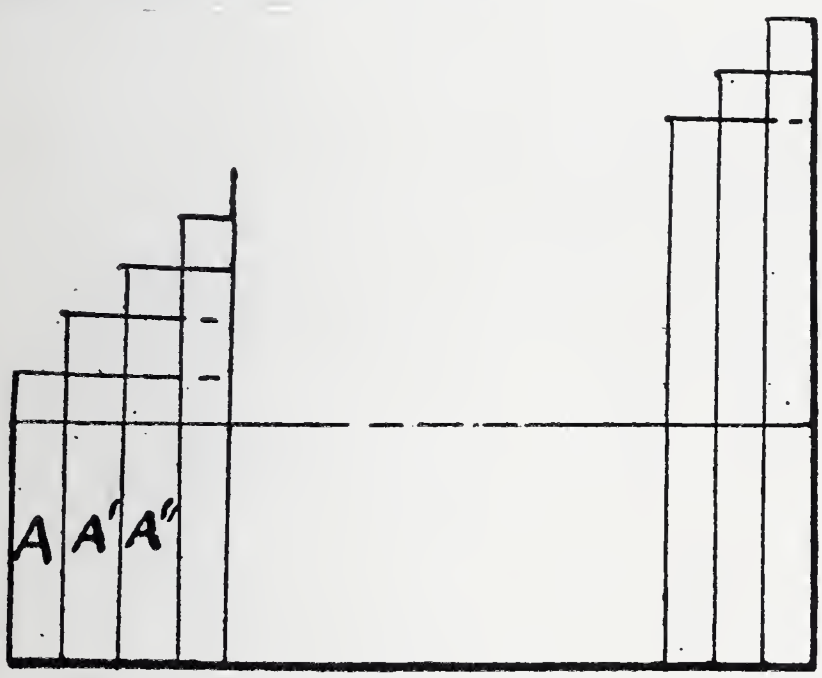
R = Rotation, 200 years.

This formula is graphically expressed by the diagram:



When the base of the triangle equals the length of the rotation, the number of steps is equivalent to the number of years in the rotation, and the height of each step equals the annual increment on any one coupe. The area of the square X is equivalent to this year's growth on the youngest coupe, the square X′ is this year's growth on the next older coupe, etc. Rectangle Z is equivalent to this year's growth on all the coupes (which is the same as 50 years of growth on that single coupe)—that is, it is "I," the annual increment of the whole forest. The area of this triangle then equals the total normal growing stock of the even-aged forest.

In the uneven-aged forest the normal growing stock would be shown graphically by this diagram:



Here the base of the triangle (and trapezoid) represents the length of the *cutting cycle.* The upper part of the figure—that is, the triangle—is exactly as for even-aged stands, but the lower part of the figure represents the volume of all the immature timber left on all the coupes. The area represented by the rectangles A, A′, A″, etc., is the amount left on any one coupe—that is, 4,000 feet per acre in the stand under consideration. By formula the normal growing stock might be expressed as follows:

$$Gn = \frac{I \times CC}{2} + \text{Res. per coupe} \times \text{total number of coupes.}$$

Gn = Normal growing stock.
CC = Cutting cycle, 50 years.
I = Annual increment on all coupes in cutting cycle.
Res. = Reserved timber on each coupe after cutting.
Number of coupes = Number of years in cutting cycle.

In the forest under consideration this would solve out as follows:

$$\text{Gn} = \frac{5{,}000 \times 50}{2} + 4{,}000 \times 50 = 325{,}000$$

It is, of course, immaterial whether this formula is computed for cubic feet or for board feet. The latter is more convenient, for the real growing stock is cruised in merchantable board feet, and growth tables are made on this basis. Were the unit the cubic foot, the trees under 12 inches in diameter would be included as well. This would have no material bearing on the application of this formula, only alter its proportions a little, there being more undersized material not measurable by the board foot unit in the reserved timber than that removed in the cutting. Professor Chapman's comments by letter, which I quote by permission, are as follows:

"Your idea regarding the formula for normal growing stock for cutting cycle of one-quarter of the rotation is absolutely correct. The normal growing stock consists of the reserve left after cutting multiplied by the area, plus one-half the growth which takes place on the entire forest for the entire cutting cycle. It needs to be emphasized that this growth is the actual total growth on the entire area and not merely the timber now mature or any portion of it. The forest may be assumed now to be in an all-aged form. Cutting on a 50-year cycle followed by an immediate reproduction of the cut-over areas would alter this to a group form in which there would be three age classes, one on each cutting area. If we assumed that reproduction was very slow and it took 50 years to complete the process on the cut-over areas, the forest would remain in its present all-aged form in spite of the cutting cycle."

The formula seems to be much simpler, and perhaps sounder, than that advocated by Barrington Moore in the Proceedings, Vol. VII, No. 1, page 15, and one which involves less unknown quantities. The length of rotation is a very uncertain and meaningless quantity in a forest cut by the selection system; foresters instead should gauge their management in selection forests by the cutting cycle. The age of merchantability which Mr. Moore's method requires is also a questionable quantity in an uneven-aged forest, where the reserved trees are very variable in size and age. The formula proposed above,

$$\text{Gn} = \frac{\text{I} \times \text{CC}}{2} + \text{Res. per coupe} \times \text{total number of coupes},$$

has neither of these variables. The length of the cutting cycle is a matter of arbitrary decision, but the amount of timber left on each coupe after its periodic cutting will govern its increment, and this in turn will affect the length of cutting cycle necessary to produce the desired periodic yield.

If increment studies have been made, therefore, the proposed formula contains no assumed quantities which are not quite largely compensating; in actual practice it is the silvicultural consideration that must govern the severity and frequency of selection cuttings rather than formulæ for regulation.

It is evident that when the forest becomes perfectly normal—that is, at the end of the rotation, 200 years hence—there will be no surplus growing stock; the increment will probably be very much larger than it is now, and the amount left (gauged on a cubic-foot basis) be much larger than it is now. The 4,000 board feet which we are actually leaving now is perhaps not the theoretically correct amount to leave, if we were carrying our plans beyond the present cutting cycle. But in making our plans for the next cutting cycle and in figuring for immediate use the normal growing stock, it seems perfectly safe to assume for the reserved stand any amount which is silviculturally all right, which for this forest seems to be 4,000 feet of scalable material, with the omnipresent advance growth of seedlings and saplings thrown in for good measure.

LAND CLASSIFICATION RULES FOR AN ARIZONA FOREST

BY JOHN D. GUTHRIE

Contributed

GENERAL

The provision for land classification in the act making appropriation for the Department of Agriculture was passed by Congress on August 10, 1912. This act authorized the Secretary of Agriculture to classify all lands within the National Forests for the purpose of segregating those lands considered to be chiefly valuable for agriculture. The classification act was the natural outcome of the Forest homestead act of June 11, 1906. The experience of the Forest Service with the Forest homestead act during six years had shown that the problems could not be finally and satisfactorily solved by the mere examination of single tracts of land individually applied for; community interests should not be overlooked; all of the economic needs of a region should be given careful consideration. Immediately upon the passage of the act of August 10, 1912, the Forest Service began to make plans for the carrying out of the law, and this important work has been aggressively carried forward in all of the districts.

During the field season of 1914, on each Forest in District 3, rules were drawn up to govern the segregation of agricultural lands. These rules have since been approved by the Secretary of Agriculture and are now in force. Prior to the drawing up of the Forest rules general classification rules had been prepared covering the general conditions in District 3—that is, Arizona and New Mexico. These general rules were approved by the Secretary before any of the Forest rules were drawn up, since the Forest rules are based on the general rules for Arizona and New Mexico.

Any set of rules for the ultimate use of National Forest land must, above all, take into consideration the economic and physical features and conditions of the area concerned, and must deal with these features and conditions in a broad way, looking toward the highest use that National Forest lands must eventually play in the economic development of the local community, the county, the State, and the general region in which they are situated.

As a specific example of such a statement of local conditions on one of the National Forests in Arizona, and of classification rules based upon such conditions, the following is given:

Statement of Conditions

The statement of conditions, forming a basis for land classification and settlement work on the Apache National Forest, with the accompanying specific rules, were prepared in July, 1914, receiving the approval of the Secretary of Agriculture on September 25, 1914. These rules now govern classification and settlement work on the Apache Forest.

The Apache National Forest is located in east central Arizona, with elevations ranging from 3,800 to 11,500 feet. The northern half is principally high, plateau; and, geologically, is included within the Arizona Plateau region—a region characterized by bedded rocks lying nearly horizontally and consisting chiefly of Paleozoic sediments resting on granite and schists of pre-Cambrian age. Volcanic masses of large volume and comparatively recent origin cover the plateau in many places, locally known as malpais. The southern half is rough and broken and is embraced within the Arizona Mountain region, which is characterized by a greatly diversified topography, by a great number of nearly parallel mountains or mountain ridges, separated by very narrow valleys, and in many cases by box canyons. Some of the valleys are fairly wide and are deeply filled with fluviatile and lacustrine deposits.

Of the net area of the Forest, 1,252,736 acres, including school lands, roughly 600,000 acres are timber land, 419,000 woodland, 22,000 brush land, 209,000 grass land, and 3,000 acres chiefly valuable for agriculture. On the east and west respectively the Forest joins the Gila and Datil National Forests and the White Mountain and San Carlos Indian Reservations, while on the north and south the woodland gives way to the grass land of the public domain.

Recent reliable estimates place the total stand of saw timber at 2,172,-000 feet, board measure, while the cord-wood aggregates 575,000 cords. Up to the present time the cutting of timber has been confined to supplying the purely local demands, but quite recently inquiries as to the terms of sale for two large bodies of timber, one involving 300,000 feet, board measure, and the other 1,000,000 feet, board measure, rather indicate that it is only a matter of a few years before lumbermen will be applying for the purchase of large blocks of National Forest timber at satisfactory stumpage rates.

At the southern end of the Forest are located the important and permanent copper-mining towns of Clifton, Morenci, and Metcalf, whose

present annual consumption of mining timbers is 20,000 feet, board measure, which comes almost entirely from Oregon and Washington, with a comparatively small amount from Texas. The Apache timber is the nearest to these towns and must soon be drawn on to supply this important local market. From present indications, a very large sale will very likely be consummated within a few years to supply the above mining towns, as well as Bisbee, Douglas, and Globe.

WATERSHED PROTECTION VALUE

Although the value of the Apache Forest as a source of timber supply is high, its value as a protection forest is even higher. The main headwaters of the Little Colorado River rise in or immediately adjacent to the Engelmann spruce areas, mountain prairies, and meadow-lands of the northern half of the Forest. The waters of this stream are at present used in the irrigation of 5,000 acres of land at Springerville, Eagar, Colter, and scattering ranches along the river between the Forest boundary and St. Johns, a town located 40 miles north of the Forest line. At this latter place 3,000 acres of land has also been irrigated for many years, and quite recently an $80,000 reservoir was constructed by the Lyman Irrigation Company, with a total storage capacity of 36,000 acre-feet; so that now an additional 15,000 acres is being placed under ditch. Still farther down the river, at Hunt, about 4,000 acres is being placed under irrigation, and the Lyman Irrigation Company has complete engineering data on two additional irrigation projects on the river between St. Johns and Holbrook. At Woodruff, Holbrook, and Winslow there are considerable areas of irrigable lands, and around the two latter places, which are on the main line of the Santa Fe Railroad, is located the proposed Little Colorado irrigation project of the U. S. Reclamation Service. This entire field of agricultural development is wholly dependent upon the protection of the headwaters of the Little Colorado River within the Apache Forest, because of the fact that the lower basin of the Little Colorado is an area of phenomenally low rainfall.

The central portion of the Forest, where the mountain prairies and meadows are also located, is the principal drainage area of the main head of Black River, which joins with White River to form the Salt River. Waterflow conditions on Black River has a direct influence on the important Salt River project of the Reclamation Service around Phœnix, as evidenced by the position which the supervising engineer of that Service has taken with respect to the diversion and impounding of the flood waters of the Black River for local agricultural use within the

Apache Forest. It is customary to refer all ditch and reservoir applications to the Reclamation Service for consideration before acting upon them, and the supervising engineer has consistently declined to approve even the exceedingly small projects on the ground that "each tract of land which is granted a water right from the tributaries of the Salt River would deprive a tract of equal size of its present water right in the Salt River Valley." In view of his further statement that "the use of this water for whatever purpose practically destroys its use, so far as the Salt River project is concerned," no permits are being issued by the Forest Service involving the use of the waters from Black River, and lands otherwise irrigable are of necessity classified as dry farming lands, since water is not available for use. The Salt River project involves the irrigation of some 230,000 acres of land tributary to Phœnix and is the most important reclamation project in the State, and in order to afford the utmost protection to the watershed on which it is dependent, sheep have for years been excluded by the Forest Service from the major portion of the drainage area of Black River at the request of the Reclamation Service.

In the southern half of the Apache Forest are found the headwaters of the San Francisco and Blue rivers and Eagle Creek, all of which are important tributaries of the Gila River, and therefore have an important bearing on the proposed San Carlos project of the Reclamation and Indian Services. There were in 1909, according to Bulletin No. 63 (Irrigation and Agricultural Practice in Arizona, by R. H. Forbes, 1911), published by the University of Arizona and officially quoted in the Governor's annual report, the following areas actually under cultivation along the Gila River and certain of its tributaries in Arizona:

	Acres.
Gila River from Monument to San Carlos, including Indian reservations	12,700
Gila River from San Carlos to San Jose	21,000
Gila River from San Jose to the New Mexico line	2,700
San Francisco, Blue, Eagle, and Pinal creeks	820
	37,220

According to the same report, there were also 14,000 acres in cultivation at Arlington and Buckeye on the Gila below the confluence with the Salt, and the total estimated acreage that could be irrigated from the waters of the Gila and its tributaries was placed at 140,000 acres. Eagle Creek is the source of the entire water supply of Morenci and Metcalf, mining towns of 6,000 and 4,000 inhabitants, and the San Francisco River the source of water supply of Clifton, a mining town

of 6,500 people—both towns located just outside the Apache Forest. The pumping plants and water system of Morenci and Metcalf alone represent an investment of $750,000.

Without question the Apache Forest is one of the most important Arizona Forests from a watershed protection standpoint, for the Gila, Salt, and Little Colorado, all of which have their principal headwaters or the headwaters of important tributaries within the Forest, are three of the four most important streams in the State, while all are important feeders of the fourth stream—the Colorado River.

AGRICULTURAL VALUES

As opposed to the high timber and watershed values, the agricultural value of lands within the Forest is insignificant. Although the gross area of the Forest is 1,276,400 acres, exclusive of approximately 136,960 acres of school lands under Forest Service jurisdiction, alienations and pending alienations total 23,640 acres to date, of which not more than 3,000 acres are actually cultivated. Of this area 16,872 acres were listed under the Forest homestead act of June 11, 1906, in 155 separate tracts. Roughly, 75 per cent of these tracts are irrigable and are for the most part used primarily for agricultural purposes. The remaining 25 per cent of the tracts listed are dry farming cases, and on some of these lands agriculture is distinctly secondary to stock raising. On the whole, however, lands heretofore acquired under the act of June 11 are put to agricultural use. The fact that agricultural lands irrigable in character have been available for entry since the passage of the act of June 11 can only be accounted for by heavy relinquishments (due to three years of drought in 1902-1904) under the old lieu land law, which made them available after listing for re-entry under the Forest homestead act.

LAND TYPES

Lands with doubtful or real agricultural value on the Apache Forest naturally fall into the following classes: Mountain prairie and meadow lands, irrigable lands, and dry farming lands in the saw-timber and woodland belts. These are taken up separately below.

Mountain prairie and meadow lands are, for the purpose of this discussion, defined as open grass lands of the dry prairie or wet meadow type, occurring at elevations of 8,500 to 9,500 feet. They comprise, roughly, 60,000 acres and 30,000 acres respectively and usually occur in large bodies and in the heart of the Forest. The mountain meadows abound in natural springs, are swampy, locally known as "cienegas," and

unquestionably have an active influence on waterflow conditions of the Little Colorado, Blue, and Black rivers; and over 35 ditch and reservoir permits have been issued for the diversion and storage of water in the former of these two drainage areas alone. The administrative value of both prairie and meadow lands is high by reason of their location in the center of the Forest and the part they play in plans for better grazing control. At present these high summer ranges are not used to their full capacity, partially because the forage, through lack of use, grows coarse and rank (the stock drifting onto the lower ranges as soon as the usual summer rains set in) and partially because the number of stock using the Forest is under present conditions limited to the number for which a badly depleted winter range on the public domain is available. The grazing plans for the Forest call for the construction in 1914 of 30 miles of drift fence, which will make possible the saving of winter range for purely winter use through forcing the cattle to remain on the summer ranges during the entire summer months. This will not in itself provide for the full use of the summer ranges; but as the agricultural development of irrigated areas outside the Forest, as, for instance, at St. Johns and Hunt, increases, it is certain that a large amount of forage will be produced so far from the railroad (50 to 70 miles) as to make its local use for winter feeding purposes necessary, and stock fed on these outside ranches during the winter months will depend almost entirely on the summer ranges of the Apache Forest for summer forage. In this way the summer ranges will within a few years become fully stocked and serve their highest economic use as an adjunct to the cultivated alfalfa ranches outside.

That these lands are more valuable for grazing than for agricultural purposes is clearly shown by the use to which they have been put in the past. There are six patented ranches in the mountain prairie and meadow region and none of them is used for agricultural purposes, although they have been in private ownership for many years. As early as 1904 and 1906 several known attempts were made to produce agricultural crops on these tracts, but in each case unsuccessfully. Only one tract in this type has been listed under the act of June 11, 1906, and the entryman recently made application for final proof. His entire residence during a period of nearly five years amounted to not more than twelve months in the aggregate and consisted of residence during short periods during the summer months. His cultivation has been confined to about one acre of land in timothy, and clearly his sole purpose for taking up the land was to secure a summer grazing headquarters. A second applicant for land under the act of June 11 was, in 1912, given

a free agricultural permit to demonstrate what the land would do. In 1913 he raised about one ton of barley hay to the acre on six acres of land. This was at an elevation of about 8,700 feet. Clearly the use to which these lands have been put in the past and the particularly adverse climatic conditions, due to the excessive elevation, limit any agricultural development to the production of small quantities of forage, for which there is no market unless provision could be made for wintering range stock at this elevation, which is not at all feasible. Economic conditions do not justify the growing of forage under these adverse conditions, in view of the bona-fide need of the land for summer range purposes in the near future in conjunction with winter feed-producing ranches. Accordingly, no mountain prairie or meadow lands should be listed, as their chief value is for grazing and forest purposes. (See Forest Rule 2.)

Irrigable lands are, for the purpose of this discussion, defined as timbered or non-timbered agricultural lands having actually available for use an adequate supply of water for irrigation purposes and suited to the permanent production of intensive farm crops. Where only a sufficient supply of water is available to supplement the rainfall by occasional waterings, wooded or non-timbered agricultural lands are considered dry farming land of exceptional possibilities and are classified under general restrictions established for such lands in the saw-timber or woodland zones, due allowance being made in applying farm-unit restrictions for increased productivity because of a supplemental water supply. Subirrigated lands fall in this latter class.

Practically all of the irrigable lands, as above defined, occurring in tracts of any reasonable size have already passed into private hands. Of the few that remain, some are so located in canyon bottoms as to block access to forest timber, while others, if cleared, would scour badly—conditions that preclude listing. The productive capacity of these lands is high. At the lower elevations alfalfa will ordinarily produce 2½ tons per acre in two or three cuttings, selling at $15.00 per ton. Corn and fruit are also grown. At the higher elevations oats is the principal crop and finds a ready market at Fort Apache (75 miles distant), the yield being about 1,100 pounds per acre. Prices range from 2 cents at Springerville to 3 cents delivered at Fort Apache. Wheat is also grown in small quantities, yielding about 1,500 pounds per acre and selling at about 2 cents a pound. Potatoes are extensively grown, the yield running about 5 tons per acre, selling at 1½ cents per pound. Under these conditions a farm unit of 20 acres seems justified. (See Forest Rule 1.)

Dry farming lands in the saw-timber type are defined as open grass lands below 8,500 feet elevation in the saw-timber type that are topo-

graphically and physically suited to the permanent economic production, without irrigation or drainage, of ordinary farm or forage crops. The remaining government-owned lands of this class occur north of the White Mountains and along the Forest boundary, at elevations ranging from 8,000 to 8,500 feet, where the precipitation is about 15 inches. Dry farming operations on such lands have been so limited that their productive capacity is largely a matter of conjecture. There are, however, known cases where oat hay averaged 1 ton per acre at $20 per ton, and oats yielded about 900 pounds per acre, valued at 2 cents. On this basis a 40-acre minimum farm unit seems justified. (See Forest Rule 1.)

Dry farming lands in the woodland type are defined as open or sparsely wooded lands in the woodland belt topographically and physically suited to the permanent economic production, without irrigation or drainage, of ordinary farm and forage crops. These lands ordinarily occur in isolated tracts south of the Blue Range, between 5,000 and 7,000 feet elevation, where the estimated normal precipitation will probably vary from 16 to 18 inches. Scattered tracts also occur on the north side of Escudilla Mountain, where the precipitation will not run over 12 inches. Dry farming has not been extensively followed on these lands, but those south of the Blue Range are producing about 700 pounds of corn at 2½ cents per pound, 500 pounds of beans at 4½ cents, and 2 tons of cane at $10, on which basis a 40-acre minimum farm unit seems justified. (See Forest Rule 1.)

The dry farming lands on the north side of Escudilla Mountain have such a low precipitation, owing to their topographic location, as to greatly reduce their productive capacity, and for such lands an 80-acre farm unit is recommended. (See Forest Rule 1.)

Since aspen lands topographically suited to agriculture occur only in small bodies and are restocking with saw-timber species, and fall under District Rule 1, there is no occasion for defining conditions under which, if occurring in solid blocks of farm-community size, they would be listed.

With this general discussion the following classification rules for application on the Apache Forest are established as supplemental to and within the general limitations of the District 3 classification rules for Arizona and New Mexico, already approved by the Secretary, to which occasional reference is made.

RULES

Rule 1.—Subject to the general provisions of District 3, Rules 1, 3, and 5, timbered or non-timbered irrigable lands and dry farming lands in the saw-timber and woodland types, as previously defined, will be

classified as chiefly valuable for agriculture and listed upon application, or otherwise when occurring in sufficient area to meet the following minimum farm-unit requirements for the various types. Only agricultural timbered or non-timbered irrigable land, open agricultural dry farming lands in the saw-timber type, or open or sparsely wooded dry farming agricultural lands in the woodland type will be credited to the requisite acreage.

	Acres.
For irrigable lands	20
For dry farming lands in the saw-timber type	40
For dry farming lands in the woodland type except those lying north of Escudilla Mountain	40
For dry farming lands in the woodland type lying north of Escudilla Mountain	80

Rule 2.—Mountain prairie or meadow lands, as previously defined, are to be classified as chiefly valuable for forest and grazing purposes, even though topographically and physically suited to cultivation, and will not be listed.

Rule 3.—Timbered or non-timbered irrigable lands and dry farming lands in the saw-timber and woodland types, as previously defined, may be classified as chiefly valuable for agriculture and listed upon application, or otherwise without reference to farm unit restrictions when adjoining agricultural alienated or listable lands. They should not be so listed, however, when this will result in making an impracticable indentation in the Forest area.

Rule 4.—Sparsely wooded land, if non-agricultural, and heavily wooded land, whether agricultural or non-agricultural, will be considered as having high watershed protective value wherever found, and will be classified as falling under District 3 Rule 4, and will not be listed except for the purpose of securing reasonable administrative lines when adjoining areas of farm-unit size. These lands and non-agricultural open or timbered lands under District Rule 1 will for this purpose only be listed in areas not to exceed the following scale:

One acre of timbered or heavily wooded non-agricultural land or two acres of open or sparsely wooded non-agricultural land to one acre of irrigable land.

One-half acre of timbered or heavily wooded agricultural or non-agricultural land or one acre of open or sparsely wooded non-agricultural land to one acre of dry farming land.

Boundary lines should be drawn as closely as consistent with good administration and the above scale used only as maxima and for the purpose given.

Rule 5.—Since the history of agricultural development on this Forest shows that in no case has non-irrigable timbered land been cleared for cultivation, no such land will be listed under District Rule 1 for the purpose of strengthening an agricultural community. In view of the conspicuous absence of agricultural development of such lands, it is practically certain that, if listed, they would not be used for the production of agricultural crops, and the purpose of the District Rule cited would not be fulfilled.

Rule 6.—Land of any description will be considered topographically unsuited for permanent agricultural use above a maximum slope of 12 per cent or where the sustained slope over the entire tract is over 8 per cent. While in listing agricultural areas it may be necessary for the purpose of securing reasonable boundary lines (within the acreage restrictions of Forest Rule 4) to include areas having a greater slope, the lands so included will be classed as non-agricultural, and will, regardless of soil characteristics, in no case be credited to the requisite farm-unit acreage.

Rule 7.—Dry farming land will be considered physically non-agricultural when its soil is less than 2 to 3 feet deep to a stratum impervious to water, the greater depth being required in regions of relatively low precipitation.

Rule 8.—These Forest classification rules are subject to reasonable exceptions in any given case upon a showing to justify such exceptions.

THE CONSTRUCTION OF A SET OF TAPER CURVES

BY W. B. BARROWS

Contributed

The first step in the preparation of a set of tables showing the taper of trees for a given species is the classification of the data. In some cases it may be desirable to divide the trees into two or more age classes. Locality and crown class may also have enough influence to make it necessary to confine one set of curves to certain classes of trees. In determining whether or not it is safe to combine certain data it is recommended that the form-quotient method be used. The diameter outside bark at half the height of the tree is calculated and divided by the diameter breast high to obtain the form quotient. By comparing the form quotients of trees of about the same height and diameter, but different classes, a decision can be reached in regard to the justification for combining or separating the data. Assuming, then, that there are at hand enough trees of one age class to make a taper table, the analyses are separated into 10-foot height classes. All the trees, for example, that are from 75.0 to 85.0 feet high are called 80-foot trees, those from 85.1 to 94.9 are 90-foot trees, etc. Then each height class is separated into 2-inch diameter classes. Trees 7.0 to 8.9 inches in diameter are called 8-inch trees, those 9.0 to 10.9 are 10-inch trees, and so on. If a "basis table" is made at this point, it will prove to be a great convenience. The following is part of a table of this kind:

Diameter breast-high.	Total height of tree—feet.					
	80	90	100	110	120	130
Inches.	Basis—trees.					
8	11	2	1	....	....	....
10	9	21	14	....	....	....
12	2	8	33	7	....	....
14	3	7	33	18	4	....
16	3	6	21	24	44	5
18	3	9	28	43	54	9

From this table a decision can be reached in regard to the limits to which the various curves should be drawn. This is of considerable help

in laying out space on the cross-section paper for the different sets of curves.

The method followed in the tabulation, which is the next step, depends on how the original measurements were taken. If the trees were measured at the cuts made by the loggers, it will be necessary to allow for the tabulation of numbers every two feet above ground. The diameter at each point is tabulated in the column nearest in value to the actual height above ground of that point. Thus diameters at any distance between 7.1 and 9.0 feet, inclusive, are entered under the "8" column, those at 9.1 to 11.0 under the "10" column, and so on. (The diameter measurements below 4½ feet will not be included in this tabulation because the differences in butt taper between trees of the same diameter but different heights are too small to be taken into account. When the butt taper is tabulated, therefore, all the heights under each diameter are tabulated together.) The sheet for tabulating diameters is in the following form:

D. b. h. and height class.	Actual d. b. h.	Height above ground—feet.								
		6	8	10	12	14	16	18	20	etc.
Inches.	Inches.	Diameter inside bark—inches.								
14 x 80	13.8	....	....	....	....	....	....	....	....	....

As indicated above, the diameter inside bark will be that ordinarily tabulated. In some cases, however, it may be necessary or preferable to tabulate the diameter outside bark.

The work is much simplified if the field measurements have been taken at uniform heights above ground. Thus, if the trees are all measured at 1, 2, 3, 4.5, 10, 20, 30, 40, etc., feet above ground, it is necessary to have columns for only those heights instead of a column for each even number. If the trees were measured every 5 feet, it is desirable to insert between the 14 and the 16 column one numbered 15; also a 25 in the proper place, and so on. This makes it unnecessary to tabulate all the 15s on either 14 or 16.

As soon as the diameters have all been tabulated, the average diameter for each height is found. Thus, suppose that there are 30 trees in the 16-inch 60-foot class, and that 10 of them were measured at 14 feet above ground. These 10 measurements total, say, 127.6 inches. The average, 12.8 inches, is the value which is plotted on cross-section paper.

Again, 13 of the trees were measured 28 feet above ground, and the average diameter at this point is 10.8 inches, and so on. A slight error is introduced by this method of getting averages because the information that is being sought refers to the volume of the tree and not merely to its diameter. It would be more accurate to find the area of a circle corresponding to each of these diameters, average the areas, and then find the diameter corresponding to the average area.

Practically, however, the error is negligible. For example, in the first of the cases mentioned above, which is from actual measurements, the average diameter found by the area method is between 12.79 and 12.80 inches, as against 12.76, which is the arithmetical average of the

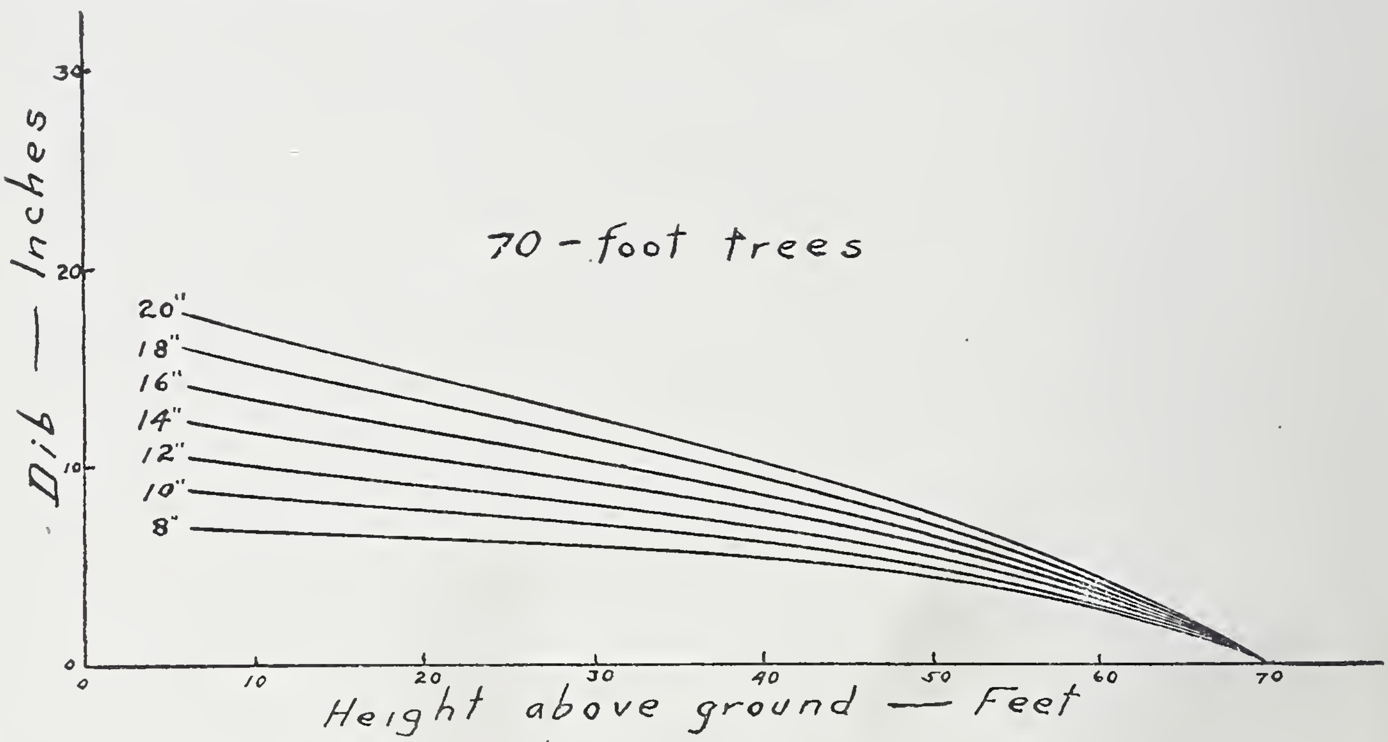


FIG. 1

diameters. In the second case the true value is 10.84, as against 10.80 obtained by a straight average. These average values, then, are plotted on cross-section paper, the abscissæ representing various heights above ground and the ordinates the diameters inside bark. The scale on the X-axis may be 8 or 10 feet to 4 inches, while that on the Y-axis is 2 inches to the inch. First, only those diameter classes which are multiples of 4 should be plotted. Beside each point as it is plotted the basis and d. b. h. should be put, in the form of a fraction. Thus $\odot\frac{19}{8}$ would mean that the point in question represents the average diameter at this height above ground of 19 8-inch trees. After these trees (8-inch, 12-inch, 16-inch, etc.) are plotted, a curve representing the average form of the diameter class should be drawn through each set of points. Next, the 6-inch trees should be plotted; but to keep them distinct from the 4s and 8s there should be a circle around each point made with blue pencil. The points for the 10-inch trees should then be plotted with red circles

around them, the 14s with blue ones, the 18s with red ones, etc. When these curves, too, have been drawn, the first curving of this height class has been completed. The other height classes are done in the same way, the general appearance of each being as here shown (fig. 1).

The first curving is now read by the strip method[1] and the resulting data plotted for the second curving. In this each height class is kept separate as before. The various points should be plotted on the actual

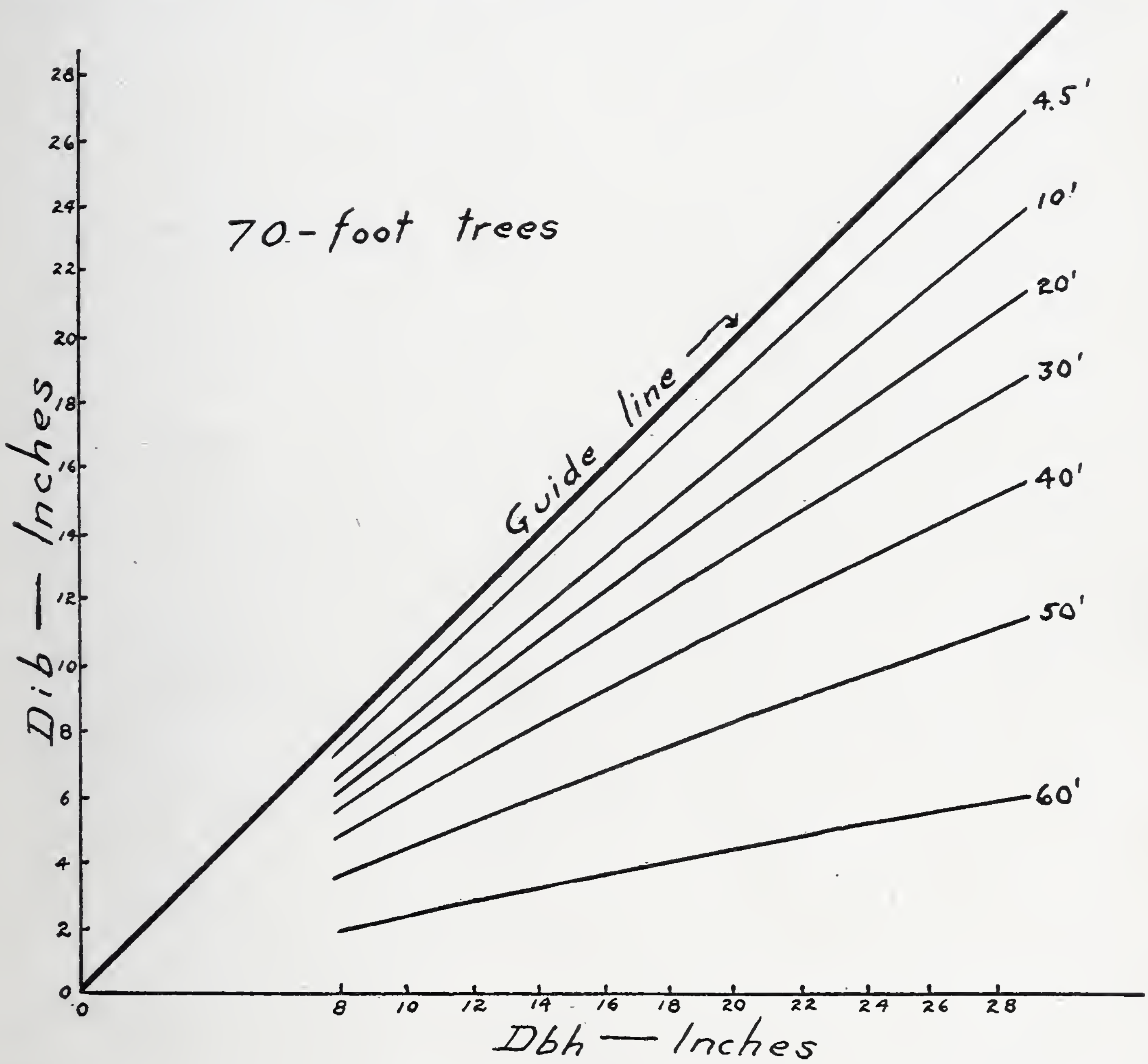


FIG. 2

d. b. h. and not on the d. b. h. class. Thus there may be 10 trees 5.0 to 6.9 inches in diameter. These will all be 6-inch trees, but the average of their actual diameters breast high may be 6.3 inches. In this case, instead of plotting the points on the 6-inch ordinate of the second curving, they are plotted on the 6.3-inch ordinate. To serve as a guide it is desirable to draw a blue pencil line at an angle of 45° with the X-axis, so that it would pass through the point where d. b. h. = 0. This curve

[1] The strip method is explained on pages 65-67 of this issue.

would have the equation d. i. b. = d. b. h.—that is, for any point on it the d. i. b. reading would be the same as the d. b. h. reading. It is obvious that the d. i. b. b. h., being less, must lie below the d. o. b. b. h., the distance between them representing the total or double width of bark. The scale on both axes is the same, 2 inches to the inch.

The points, then, are plotted on the actual d. b. h. and are now curved (fig. 2). In the third curving there is a set of curves for each diameter class, and therefore, in curving by the strip method, there should be a strip for each diameter. In figure 3 one diameter class is represented,

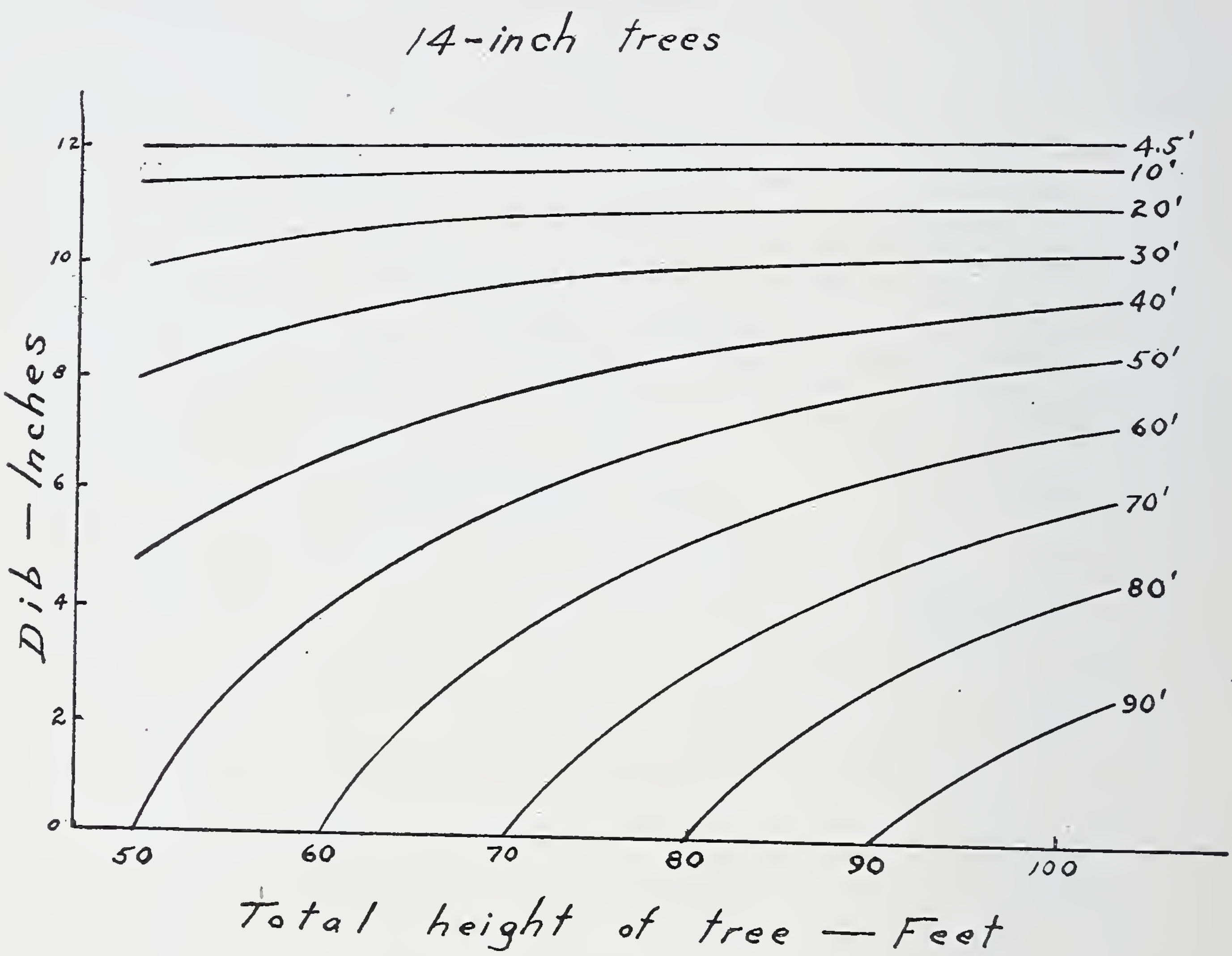


FIG. 3

this being one group of curves of the third curving. The abscissæ are the total heights of the trees on a scale of 5 feet to the inch. The ordinates, as in all the other curvings, are diameters inside bark on a scale of 2 inches to the inch.

Each curve represents the diameter inside bark at a certain height above ground of all trees of one diameter breast high, regardless of total height—that is, one group of curves or one diameter class includes several height classes. The purpose of this curving is to make more regular the differences between measurements at equal heights above ground in trees of the same diameter in the various height classes. Thus, if this

curving were omitted, the final table might indicate that trees 16″ by 60′ were 10.0 inches in diameter, those 16″ by 70′ were 9.9 inches, and those 16″ by 80′ 10.4 inches in diameter, all being measured at a point 30 feet above ground. It will be noticed that some of these curves intersect the X-axis, since, for example, the diameter of a 60-foot tree 60 feet above the ground is zero.

The fourth curving is like the second, and the fifth is like the first in appearance and structure.

If the original trees have been measured at uniform distances from the ground, the first curving will be in the form of what has here been described as the second curving (fig. 2), and only three additional ones will be necessary.

If the original measurements were made outside bark and the taper inside bark is wanted, the bark had better be curved separately. In many cases it is desirable to measure the diameter outside bark at regular intervals. Thus all the trees would be measured at 1, 2, 3, 4.5, 10, and 20 feet above ground, and so on every 10 feet to the top or to a point where the stem becomes unmerchantable, or to some other point decided on in advance. If logging operations are being followed, as is usually the case, the width of bark can be measured at the ends of the logs. When these measurements are entered on the blank their distances above ground should be indicated in some way, so that there will be no confusion in regard to the part of the stem to which they apply. It is not necessary to tabulate the width of bark, because it can be plotted directly onto the cross-section paper from the original stem analyses. Along the X-axis two different scales are used. Up to 4½ feet the scale is 2 feet to the inch; above that point it is 10 feet to the inch. Along the Y-axis the scale is 1 inch to the inch for single width of bark (width measured along one radius), which is equivalent to 2 inches to the inch for double bark. The bark is plotted, then, while the analyses are still separated into the diameter and height classes spoken of in the first paragraph. After the curves are drawn they are read, and the values are subtracted from the average d. o. b. values shown on the tabulation sheets. This can best be done by two persons. For example, suppose that the 12-inch 70-foot trees are under consideration, and that the average d. o. b. of these at 10 feet above ground is 11.1 inches. The one (A) who has the tabulation says "10." Then B, who has the bark curves, reads the double width of bark at 10 feet above ground for the curve representing this class and finds it to be 0.9 inch. B reads this value to A, who enters it on the sheet, subtracts it from 11.1, and puts down the d. i. b., which is 10.2. A then reads the height above ground at which the

next average dob is found, and B reads off the corresponding double width of bark. After all the d. i. b. values have been found, they can be plotted as previously explained.

The great value of taper figures is that from them it is a comparatively simple matter to prepare volume tables in board feet, ties, poles, mine timber, or other products whose specifications call for measurements without bark. In making board-foot volume tables it is possible to vary the top diameter to conform to various intensities of utilization and to

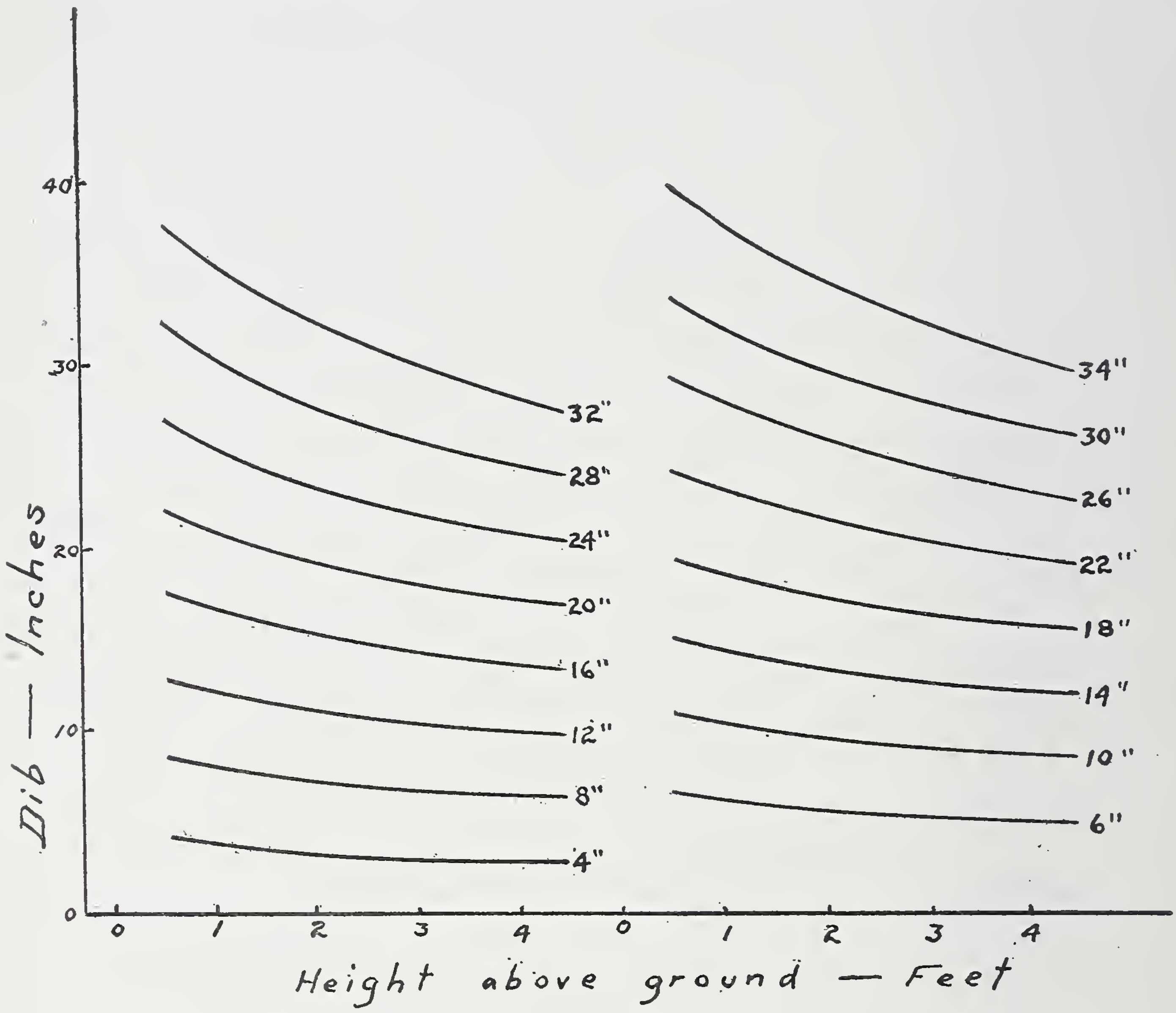


FIG. 4

prepare tables for different log rules. Cubic-foot volume tables can also be prepared from taper tables; but if volumes including bark are wanted from d. i b. tapers, it will be best to find peeled volumes first and add a certain percentage for bark. The procedure of finding the correct factor for converting peeled to unpeeled volumes is as follows: Find the volumes with and without bark of each of 10 to 20 trees 8 inches in diameter, and do the same for an equal number of 12-inch, 16-inch, 20-inch trees, and so on, selecting each diameter class which is a multiple of 4. By subtraction find the volume of bark of each tree; divide this by the unpeeled volume, and multiply by 100 to get the per cent of bark of that

tree. Find the average of the percentages of the trees of each diameter class and plot these values on cross-section paper, using the average diameters as abscissæ and the average per cents of bark as ordinates. If it is obvious that these points lie in such positions that a curve can easily be drawn through them, this curve can be drawn at once, and then the values of the average per cent of bark of trees of each diameter can

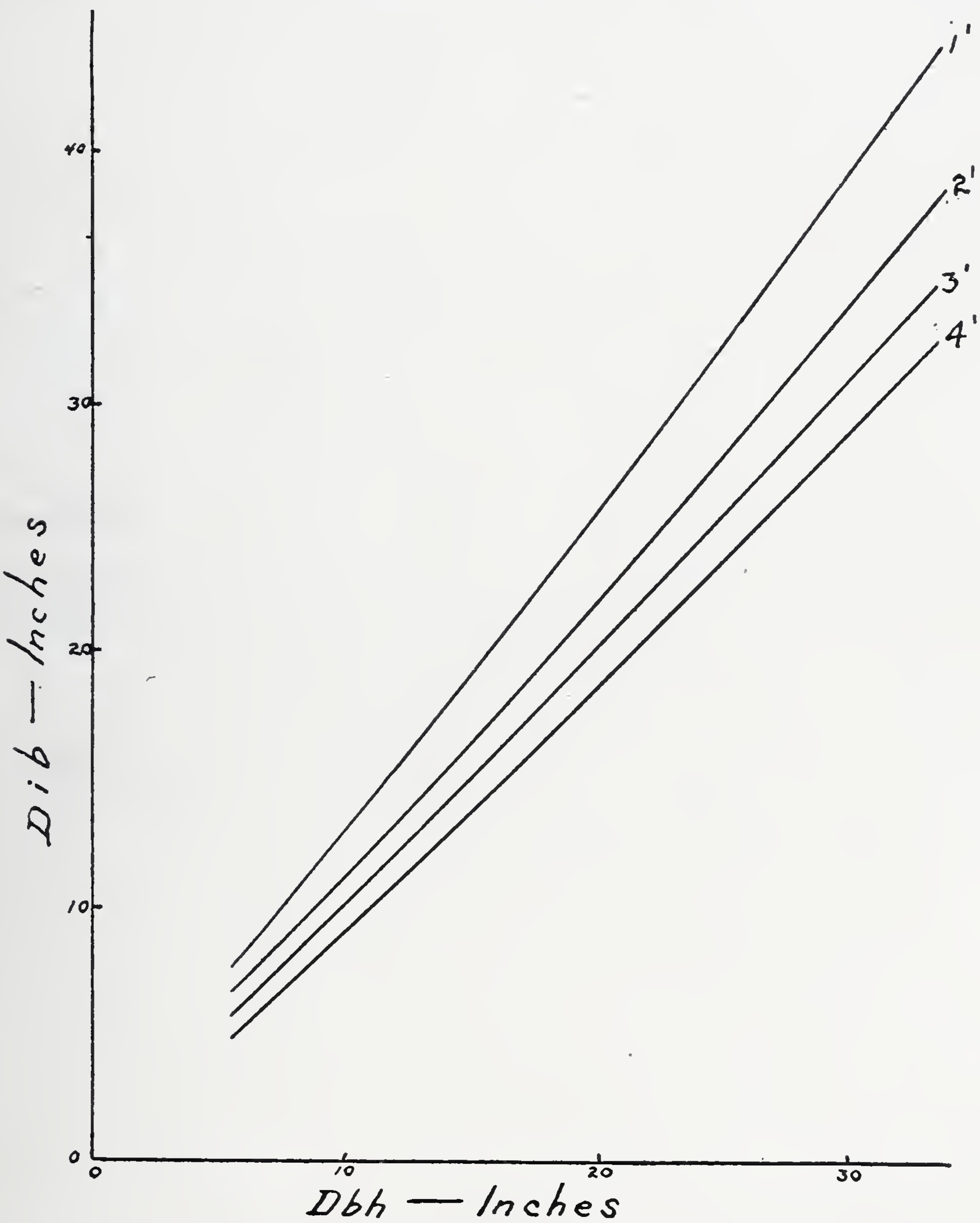


FIG. 5

be read from the curve. If, however, the points are irregularly spaced, so that it is difficult to tell just where the curve should pass, it is advisable to calculate the percentage of bark of 10 or 20 trees of each of the other even diameter classes (6, 10, 14, etc.) and to plot the additional points thus obtained before attempting to draw the curve.

In selecting trees for this purpose it is better to use trees of about average height and not to include the tallest and shortest ones, because these are more apt to have abnormally thin or thick bark.

Butt tapers should be tabulated and curved separately because the rapidity of taper is so great, and also because for each diameter class trees of all heights may be averaged together. The following is a heading suitable for this purpose:

Actual d. b. h.	Height above ground—feet.							
	.3	.6	.9	1.2	1.5	1.8	2.1	etc.
Inches.	Diameter inside bark—inches.							
....	.....	......	......	....	....	....	....	....

Diameters of .8, .9, and 1.0 foot are tabulated in the column headed ".9"; those 1.1 to 1.3 under "1.2," and so on. This form is also suitable for diameters outside bark in case those are required.

In plotting the averages obtained from this tabulation a scale of half a foot to the inch is used along the X-axis and a scale of 2 inches to the inch along the Y-axis. Plot the 4, 8, 12, etc., diameter classes separately from the 6, 10, 14, etc., classes, as shown in figure 4. The second curving will have the form shown in figure 5, in which the scale is the same in both directions, 2 inches to the inch.

Ordinarily two curvings are enough for data of this kind; but if the curves were very irregular, a third curving could be made, which would be similar in form to the first (fig. 4).

SAND-DUNE RECLAMATION ON THE COAST OF NORTHERN CALIFORNIA AND SOUTHERN OREGON

BY FRANK B. KELLOGG

Contributed

OCCURRENCE OF SAND-DUNE AREAS

Areas of shifting sand are found on every continent of the globe. Great drifts, some 200 feet in height, are found in the central portion of Australia; many hundreds of square miles are occupied by seaside sand-dunes on the coast of Europe; one-ninth of the Great Sahara Desert of Africa is composed of shifting sands, and many sand heaps and ridges have accumulated at the mouths of rivers, on the lake shores, and on the sea-shores of both the Atlantic and Pacific coasts of America.

Among the notable sand accumulations in America are those of Capes Cod, May, and Henry; along the margin of the Great Lakes; along the banks of the Columbia River; near the mouths of the Siuslaw, Umpqua, Coquelle, Smith, Tenmile, and Garcia rivers; at Humboldt Bay; on the peninsula at San Francisco, and near the sea-shores in Monterey and San Louis Obispo counties, California.

The particular region of the sand drifts described in this paper is that found a little south of Lake Tallawa and extending north to the mouth of the Smith River, Del Norte County, California.

EXTENT OF WORK DONE TOWARD RECLAMATION

Many thousands of dollars are spent annually in other countries in order to prevent the shifting of sand. In Europe, along the coast of France, Germany, Denmark, and The Netherlands, this work has been largely undertaken by the respective governments of these countries through permanent corps of foresters and engineers in charge of the work of reclamation, and many thousands of acres have thus been permanently fixed and made to serve a useful purpose in growing trees.

In this country, however, comparatively little has been done in the way of reclamation by the government. The State of Massachusetts has undertaken considerable reclamation work on Cape Cod, and in a few instances cities like San Francisco have conquered the drifts; but, for the most part, work accomplished along this line so far has been undertaken by individual or corporate effort. On the Pacific coast attempts have

been made by the railroads crossing the Mojave Desert to prevent the sand from covering their tracks. Similar attempts have been made by the Southern Pacific to prevent the encroachment of the coastal dunes in San Luis Obispo County and by the Oregon Railway & Navigation Company along the banks of the Columbia. The city of San Francisco has been very successful in reclaiming its dune land near the ocean and has turned about 500 acres of it into what is known as Golden Gate Park. Private individuals have attempted work of fixation of sands at various points between Point Reyes, California, and the mouth of the Columbia; but one of the most extensive pieces of this work is that undertaken in the region to be described in Del Norte County, California.

PURPOSE OF THE INVESTIGATION

The object of this paper is to give a brief account of sand-dune reclamation in general and to set down in writing an outline of the methods used in this work, carried out on an extensive scale for over 15 years, near the Oregon line in California, with particular reference to that part of it which might be of suggestive value in the management and reclamation of similar sand-dune areas situated on the Siuslaw Forest in Oregon.

ORIGIN AND FORMATION OF SAND-DUNES

Much of the sand from which the dunes and sand wastes are formed has its origin in the watersheds of streams and rivers. This sharp-grained river sand is washed down with the stream current to the mouths of rivers, and there deposited or carried by the longshore currents of the ocean, and dashed up on the sea-shore by wave action. The sun and wind dry the wet sand, and the wind then scurries or lifts it continually, urging it farther from the sea-shore deposit. The sharp sand of the small stream is so acted upon during its course down the river, by the churning of the ocean waves, and polishing due to wind action, that it is very much worn down and rounded when finally deposited on land. In being shifted from the sea-shore the sand on the Pacific coast travels in the prevailing direction of the summer winds, and although the winter winds, accompanied with rain, may have a high velocity, comparatively little sand is shifted, due to its cohesive power when wet. The sand in shifting from one position to another heaps up into what are known as dunes, which may have many forms, depending upon the force and direction of the prevailing wind and the obstructions encountered. A typical wandering dune, however, has a gradual slope toward the wind up which the sand particles are shifted, and an abrupt slope on the lee side, where

the atmosphere is at rest and the grains drop merely by gravity to the bottom of the dune. A typical artificial dune has a slope on the windward side from 4 to 12 degrees, and on the lee side from 20 to 30 degrees. Obstructions vary the slope of the dune and the rate of progress and are taken advantage of in order to hold the sand in place and form protected areas to the leeward. Some of the more usual natural obstructions are rocks, marshes, and trees.

On the area examined it is probable that the greater part of the sand had the drainage area of the Smith River for its source, although it is possible that the longshore currents may have brought a small amount of it from the Klamath or Chetco rivers. In this connection it has been observed that much of the driftwood and logs to be found on the seashore near the mouth of the Smith River come from the Klamath River, over 20 miles to the south. When examined under the microscope, the grains of sand show a great variety of composition and color, which is what might be expected from the mountain watershed of the Smith River, since extensive prospecting has proved it to be highly mineralized. This is quite a contrast to the sands on the North Atlantic coast, which consist of a high percentage of pure quartz.

TOPOGRAPHY OF THE AREA

A typical cross-section (fig. 1) of the area studied would present: First, the Pacific Ocean; next, the beach sloping up from this gradually, and composed of compact sand or sand and gravel; then rising rather abruptly is the sea-wall, with its accumulation of driftwood, sand, gravel, banked up in uneven-shaped forms, varying in width from 100 to 300 feet. Behind this, and usually at a lower elevation, are found either sand hummocks or else a more or less level stretch, varying in width from one-eighth to one-half mile, consisting of sand or sand and smooth gravel, with here and there marine shells, being either barren of vegetation or covered with a spare growth of sand grass (*Poa douglasii*), yellow sand verbena, wild strawberry, or shore morning-glory. Then the sand rises toward the barrier dune, which is from 100 to 500 feet wide and from 10 to 50 feet high, in many places formed artificially by fencing and planting of beach grass or marram (*Ammophila arenaria*), sometimes formed naturally by the encroachment of the sand on groves of pines or thickets of willow. Behind the barrier dune and protected by it comes a more or less level stretch of from one-eighth to one-fourth mile of territory seeded up to native grasses, clovers, sedges, and rushes. When breaks in the barrier dune have occurred, long streaks of pure

sand have shifted across the stretch to the second protection dune. It is evident from the soil that parts of this area were formerly valuable meadow-land interspersed with wandering dunes; but since the main source of supply has been stopped by the barrier dune, a large amount of the sand from the wandering dunes has shifted over into the second protection dune and has been held there, while the sand remaining has spread out over the meadow and formed a thin covering over all of it, thus decreasing its value for production of plant growth. The second protection dune, when found naturally, is where former sand drifts have encountered lodgepole and Sitka spruce groves and have been stopped from shifting long enough to be seeded down to plants such as small sand grass, wild strawberry, sand burr, huckleberry, rush, Oregon grape, salmon berry, etc.; where artificially formed, fencing and beach grass have been used, and the dune protects valuable meadow-land extending from one-eighth to one and one-half miles before reaching the lake or marsh. Here and there in the meadow are found isolated hills or groups of hills having a southeast trend, rising above the general level of the meadow, usually having trees on the lee side and marking the remnants of an early inundation of sand drift. Wherever cattle trails have crossed the northwest end of these hills the sod is broken and the wind starts to bore into the hill, sometimes uprooting the trees and completely demolishing the hill. It is here that the placing of brush to break the force of the wind is found most valuable and economical. In some instances, where ranchers have been careless about overstocking their places, these old dunes have had their vegetation totally destroyed and have become wanderers again, spreading their sand out over the valuable meadows or filling in the lakes and ponds. Occasional low places, called swales, dot the meadow in which the water accumulates during the winter, and here cut grass (*Carex sp.*) and willows characterize the growth.

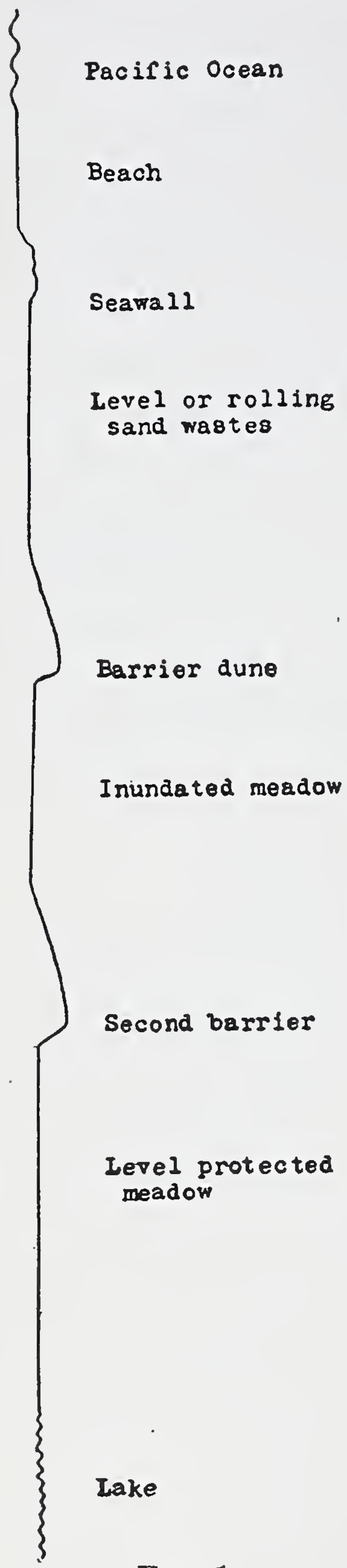


FIG. 1

DAMAGE DONE BY SHIFTING SAND

Much damage has been done by the continual shifting of sand, both in foreign countries and in our own. In many places traffic has been obstructed by the obliteration of wagon roads and railroads, valuable lands have been devastated, forests covered up, and the destruction of villages threatened by the advance of the sand. Great loss has been occasioned by the sanding up of navigable bodies of water, and the increased difficulties of dealing with the problem of harbor works is causing the loss of thousands of dollars.

So serious has been the menace to property by shifting sand that laws have been passed from time to time aimed at protection from this. An ordinance imposing a fine of from 2 to 5 pounds on any one who shall cut, etc., any brush or brushwood on the waste lands lying along the coast of Port Elizabeth, Cape Colony, was passed in 1826. Under both Louis XVI and Napoleon I great interest was evinced in sand-dune reclamation. Private properties or communes were obliged to take their share of the work, and in case of their failing to do so provision was made whereby the Public Administration took the matter over, for in a decree dated December 14, 1810, we read: "In the case in which the dunes shall be private property, the plans will be published as prescribed; and if the owners of the said private property or communes find themselves incapable of executing works ordered, or refuse to do so, the Public Administration shall be authorized to see to their plantation at their expense, and shall retain possession of the dunes and collect all proceeds from them until complete recovery shall have been made of the expenses which have been incurred and the interest thereon; after this the dunes shall return to the proprietors under the burden of maintaining satisfactorily the plantation thereon." In our own country, at Cape Cod, for many years there existed a "beach-grass committee," empowered to examine private lands and to cause them to be planted with beach grass.

The Federal Government finds it necessary to spend thousands of dollars annually in the improvement of harbors and the keeping of waterways open to navigation on the Pacific coast; a large part of such annual expenditure could be done away with by the introduction of a system of sand-dune reclamation to prevent shifting sand from filling in the waterways.

GENERAL METHODS OF SAND-DUNE RECLAMATION

Various methods to reclaim shifting sand have been used on this continent, in Australia, in Africa, and especially in some of the countries

of western Europe. The fundamental principle is to prevent the access of the direct force of the wind to the sand surface. To accomplish this, four methods, or combinations of them, in the main, have been used:

(1) Covering the surface of the sand with some inert material, as clay, street sweepings, or other refuse. When the surface of the soil is covered with inert material, such as street sweepings, if this can be maintained in place, it not only prevents the shifting of sand, but has the added value of fertilizing the soil and making the raising of some kind of plant growth easier. This method of reclaiming sand has been undertaken by such cities as Cape Town and San Francisco, where tracks are run from the city to the shifting sand and the street sweepings dumped onto the area. Although quite satisfactory where this supply is available and the city must charge the cost of disposal against the street-sweeping department, this method could not have general application to reclamation works, because of the distance from the source of supply and the consequent excessive cost of transportation.

(2) Covering with prostrate fagots or brush to decrease the velocity of the wind and create counter-eddies. In Europe, where hand labor is cheap, fagots are often bound together and placed on the surface of the sand; thus, in a large measure, preventing the drifting and causing it to accumulate in the space between the fagots. Brush is also used for the same purpose in Europe, and has been used in Del Norte County to some extent. When an open inflexible object is used, the sand deposits on all sides and between the object. If the brush is near at hand, this is an inexpensive method and has been used to advantage in filling in breaks after other methods of extensive reclamation have been used.

(3) Setting out plants or sowing seed. Many experiments have been made, both here and elsewhere, to secure plants which will grow successfully in the shifting sand. Among those plants which have been tried with some degree of success are: Hottentot fig, sand verbena, lupines, broom, sea lyme, grass, esparto, leptospernum, cytis, tamarix, and many varieties of poplars, willows, pines, firs, spruces, larches, acacias, and eucalyptus. None of these have succeeded so well in the north temperate zone as beach grass (*Ammophila arenaria*). Trees, as a rule, have not succeeded when planted or seeded before reclamation on shifting sand, although it is usually the aim to permanently fix the sand by the use of some tree growth after temporary fixation.

(4) Making fences of brush, pickets, slats, or upright fagots. Fencing is employed chiefly to hold the shifting sand in one place or cause it to accumulate in other places. The fences of Europe are made mostly of brush or fascades, built in rectangular shape, inclosing blocks from 8 to

12 feet on each side. The brush or picket is driven in lengthwise, leaving a space between pickets about equal to their diameter. In Del Norte County the use of slat fencing has been employed very effectively, not only to keep stock from wandering over exposed portions of the dune, but to arrest the progress of the drift also.

Usually the first step in the reclamation of seaside sand-dunes is the formation of a littoral or barrier dune. This is formed near the sea-coast or source of supply, just far enough back from the ocean to avoid damage from the waves during storms, having a gradual slope away from the direction of the prevailing winds and a steep slope on the lee side. The sand is rolled up the gradual slope by the action of the wind, and, meeting with some artificial obstruction, piles up into a high ridge or dune, which is kept continuous, with no breaks, at right angles to the prevailing direction of the wind. Littoral dunes of this kind grow in height with astonishing rapidity—much more rapidly in most cases than would trees planted in the same situation—and form excellent wind-breaks for the territory to the leeward of them.

OBJECTS TO BE ATTAINED AND METHODS EMPLOYED

The objects to be attained in the sand-dune reclamation on the area studied were:

(1) To prevent the sand from drifting onto lands which were valuable for agriculture, grazing, or for their production of timber.

(2) To do the work in the shortest possible time and with the least expenditure of labor and money.

(3) To finally form a more permanent protection from drifting by the use of beach grass and trees.

(4) To grow something useful on the dune, aside from the reclamation use.

(5) To improve or reclaim lands already denuded.

(6) To make use of the barrier dune and of trees for wind-breaks.

The method taken to accomplish the first was to form a continuous barrier dune at right angles to the prevailing direction of the wind by placing in the ground posts every 8, 10, or 12 feet apart, and nailing 1 by 6-inch rough refuse redwood boards, starting at the bottom and spacing with not more than 4 inches between boards. If a solid board fence is erected, the sand is piled up in front of it instead of behind it, and more lumber is required. The sand piles up behind this fence in some cases as much as 3 feet during one season, and when the drift is level with the top of the highest board more boards are nailed above this,

observing the same spacing. Where the drift accumulated very rapidly before a good barrier dune was formed, it was found necessary to build as much as five fences, one on top of another, and to obviate this difficulty posts 12 or 14 feet long were planted to save the expense of setting, in ordinary length, posts every four or five years. This method was adopted in preference to using brush or fagots, because it formed a more permanent barrier, one which did not have to be watched so closely during high winds or because of the presence of stock. The initial expense is greater, but the advantage for that locality seemed to be in favor of the board-fence method for the following reasons:

The cost of refuse lumber was low at the mill, 4 miles distant.

The fence could be built and repaired at a time of the year when labor was plentiful and cheap.

The stock could be effectively prevented from trailing the sand barriers, whereas if brush were used it would have to be hauled a mile or more to the point of reclamation, and would require constant care and attention during the busy summer season, when the sand is drifting most, to repair breaks in the fence by the gullying-out effect of the wind or the displacement of the fence by stock.

The system of board fencing alone, however, was incomplete. For instance, if it should happen that the lowest board of the fence should become displaced during times of violent northwest wind, the wind, instead of being checked in its course through the fence, would have its velocity increased, and the tendency would be not only to shift the sand in long streaks past the barrier dune, but to actually excavate around the posts and cause them to topple over. This would entail the patrol of the line of the barrier dune during several of the spring and summer months, adding greatly to the cost of reclamation.

In order to obviate this difficulty, a system of beach-grass planting was adopted in conjunction with the fencing. The beach grass was planted at a distance of from 6 to 20 feet on the lee side of the fence, the distance depending somewhat on the shape of the barrier and the amount of sand to be shifted upon it. The plants were placed in rows parallel with the fence, from 12 to 18 inches between the rows, and the same distance in the row, the spacing varying with the slope and the position to which it was desired to heap the sand. As a rule, it was found economical to plant five or six rows in quincunx form, and later, as the sand was heaped up and formed a larger hill, to plant other rows to the lee of this, sometimes leaving an intervening space, which eventually was closed up by the spread of the grass roots or by natural reseeding. This plantation arrests the sand and makes it stay in place far better than when held

merely by the fence. If a board is displaced from the fence, even during storms, the few rows of grass in a large measure prevent its drifting and therefore obviate the necessity of patrol. It also makes it possible to do with less fencing, for the shape of the dune changes and its highest point is no longer the position of the fence, but is located where the grass is planted. When the barrier dune becomes broad and high and well covered with beach grass throughout its extent, it will be sufficient, without fencing, to prevent any ordinary inundation of sand, providing stock are excluded from the area. When unrestricted grazing is allowed, however, the tramping done by stock, as well as the cropping of beach grass, is apt to interfere with reclamation. This is not due so much to the amount of fodder consumed as to the fact that the stock eat only the tender shoots of this grass, and that most of the tender shoots are found where the sand is drifting onto the area most rapidly, and is therefore most in need of fixation.

The question might be raised whether or not this form of fixation should be the final one, and whether forestation would be preferable; and, if so, why it should not be undertaken before the formation of the littoral dune and save the expense of reclamation by beach grass, and possibly by both beach grass and fencing. European experience has shown and indications are on the Pacific coast that trees cannot be grown successfully on the sandy lands immediately adjacent to the ocean. One reason given by Europeans is that the salt spray affects the foliage disadvantageously. The experience of Superintendent McLaren of Golden Gate Park has been that the trees cannot stand the climatic conditions close to the salt water. However this may be, it is best to reserve a strip of dune area above the high tide, broad enough to establish the littoral dune, as a protection to plantations. Experience has shown in Europe also that tree growth cannot be started on dry, exposed positions in the sand without first preventing the surface from shifting, and indications are that attempts of this kind on the average shifting area would meet with failure on the Pacific coast also. It then becomes necessary to plant some other crop first to reclaim the area, or else to put up wind-breaks to prevent the sand from shifting away from or upon the tree roots. The formation of the barrier dune, then, in either case is of great advantage, and in the latter case seems to meet the requirements most economically and efficiently.

From the European standpoint the final form of fixation to be attained in sand-dune reclamation is through forestation, partly because this is the most permanent form of fixation and also because forests yield the best revenue there. On the Pacific coast local conditions would influence

the desirability of different forms of reclamation, and this would be largely governed by the purpose for which the adjoining land was to be used. Where lands to be reclaimed are adjacent to areas to be devoted to the production of timber on a National Forest, or where wind-breaks are much needed for protection against the violent northwest wind, tree growth would be more satisfactory. Where the neighboring lands are devoted to dairying or stock raising and no tree wind-breaks are needed, probably permanent fixture by beach grass would be of more value, because of the grazing use to which the grass can be put. This form of fixture, however, to be permanent, must be regulated.

On the coast of northern California and southern Oregon the velocity of the wind is very great and the northwest trade-wind blows nearly every afternoon during the summer season. For this reason the value of the barrier dune as a wind-break to protect stock, to prevent cultivated land from blowing away, and to protect plantations of young trees is appreciable. In the latter case it is sometimes possible to plant trees for some distance in the lee of the barrier without having the sand shifted away from the tree roots, and the young trees have a chance to grow large and thrifty before receiving the full force of the wind above the area protected by the barrier. In Europe this protected area is sometimes sown to broom and pine or spruce. A proportion proving satisfactory in some parts is 5 pounds marram, 11 pounds cluster pine, and 7 pounds broom. Where marram seed is sown alone, from 12 to 15 pounds per acre is used. Sowing takes place either in the fall or spring, according to temperature or moisture conditions; but usually the fall is preferable, because there is less danger from excessive drying out or sand shift. The sand must be held in place while the young plants are starting, and in order to accomplish this brush is scattered for shelter. Sometimes a fence is built on the margin of the zone protected from wind by the barrier dune to form a protection against the shifting of soil by winds coming from a direction opposite from that usually prevailing. The tree plantation is started, beginning at the fence and continuing as far as this influence is felt in preventing soil shift, and later planting up the intervening territory, which receives protection on the lee side by the older trees of the plantation. In some instances along the Pacific coast a modification of this method of tree plantation could be employed, and in many instances the erection of the lee fences could be omitted because of the general lack of sand shift during the period of southeast winds.

The value of the barrier dune as a wind-break to protect dairy and dry stock is worthy of special consideration. It is well known among

dairymen having ranches along the coast much exposed to the northwest winds that the milk flow will decrease on windy days. A large dairy owner north of Smith River, who weighs each day the amount of milk produced by his herd, states that in spring and summer the milk flow falls off as much as 16 per cent during the windiest days when the cattle are pastured in exposed fields. Where the barrier dune acts as a windbreak to agricultural lands immediately back of it, crops thrive better because of the better protection from drying out and what is known as burning of the plant, and the soil may be cultivated to better advantage without fear of being carried away.

GROWING SOMETHING USEFUL ON THE BARRIER DUNE

The value of the barrier dune for protection and reclamation purposes has been discussed, but large tracts of dune planted to beach grass have a certain value for grazing purposes which, if properly regulated, may be utilized by the stockmen with profit and with little damage to reclamation. A few of the most important considerations under regulated grazing of dunes follow: Of primary importance in this connection is the maintenance of the continuity of the barrier dune. Care should be taken, therefore, to prevent the stock from forming a pathway across the barrier in such a way as to shift the sand or destroy the vegetation on the windward side, thus inducing the wind to form a blow-out at this place. Where isolated dunes occur, care should be taken to protect the head of these from the tramping of stock by piling brush there; or, if necessary, to make them take a different route by stretching a short wire or other fence to act as a drift.

The first year after planting stock should be kept away, in order to prevent them from pulling up young plants. Where the sand is piling up very rapidly upon a plantation and the tender young shoots are struggling up through the sand, stock should be excluded during late fall, winter, and early spring, because it is at this time that they are very fond of eating the tender young shoots of marram.

Considerable difference of opinion has existed among botanists and stockmen as to the value of beach grass for fodder, some writers, such as Baron von Mueller, claiming that it has no value for this purpose, while some stockmen, particularly from Australia, claim the contrary. In order to determine this matter, a complete chemical analysis was made of this grass and the results detailed in a thesis written in 1904 by F. B. Kellogg. The samples tested were from the sand-dunes of Del Norte County and from San Francisco, and were taken at different

stages of growth. Briefly stated, the results obtained through chemical analysis showed that the young, tender shoots had a good food value, but that the old, dry culms were very poor in nutritive value, consisting mainly of crude fiber. In the following table is a comparison between the young shoots of marram, alfalfa, English rye grass, and oats, expressed in percentages and on the water-free basis:

Species.	Ash.	Protein	Fiber.	Nitrogen free extract.	Ether extract.	Condition.
Marram.........	6.2	12.68	38.81	38.10	4.2	Green shoots.
English rye grass	8 7	11.7	18.4	57.6	3.6	Head invisible.
Oats	6.1	10.9	34.3	46.0	2.7	Seed in milk.
Alfalfa..........	9.7	21.4	19.5	45.1	4.3	Before bloom.

It will be seen from the above table that with reference to the most important ingredients, protein and ether extract, that the young shoots of marram are not as valuable as alfalfa, but more so than English rye grass or oats.

The experience of stockmen in Del Norte County since this analysis was made has borne out the conclusion that the young shoots of this grass are a valuable stock feed, and all the more so because they are found at a time of the year when feed is scarce.

DESCRIPTION OF THE GRASS

The grass under consideration is called by the following names: Beach grass, marram, marrem, Gourbet, and sea matweed (*Ammophila arenaria* Link., *Ammophila arundinacea* Host., *Psamma arenaria* Roem. and Schuet, *Arundo arenaria* Linn., *Calamagrostis arenaria* Roth). This grass is sometimes confused with sea lyme grass (*Elymus arenarius* L.), but sea lyme grass has a many-flowered spikelet and a broader leaf with a bluish tinge to it. Following is a complete botanical description of *Ammophila arenaria:*

Habit.—A tall perennial, growing in tufts, and with many branches at the base. Stems 1½ to 3½ feet high and nearly solid; nodes large and smooth.

Leaves.—Long and rigid, ligule 1/3 to 1 inch long; torn, membraceous, acute, and bifid when old. Blades uniform; width, 4 mm.; convolute, smooth without, scabrous within.

Panicle.—Spikelike and dense, 3 to 9 inches long, yellowish, pedicles scabrous.

Spikelets.—One-third to three-fourths inch long, erect, compressed laterally on peduncle, 2 to 5 mm. long. Rachilla scabrous and flattened, terminates in point beyond the insertion of the palea.

Bracts.—One-third to five-elevenths inch, lanceolate, acute, emarginate, awnless, or very short; pubescent at base, 3 to 5 nerved, compressed, thin, chartaceous.

Palea.—Size of bractlet, acute, 4-nerved, grooved, between inner pair of nerves, hairs and rudiment less than half as long as the spikelet.

Lodicules.—2, 2 mm. long, acuminate, membraceous.

Stamens.—3, anthers yellow, linear.

Pistil.—1, stigmas 2, feathery, styles short, distinct grain, ovoid, inclosed, but not adherent.

The root is long and fibrous. The creeping rhizomes extend horizontally for a great distance, and their course is indicated by a succession of plants which spring from them and which diminish in size as the rhizomes extend from the parent plant.

This plant has the power to continue growth upward when buried by sand by sending out new roots from the nodes. In some cases the grass is said to have grown up 60 feet above its original level, and seems to actually grow more vigorously when in exposed positions. This peculiarity, combined with its great root system and the toughness of its old leaves, makes it peculiarly fitted for sand-dune reclamation in the north temperate zone.

Beach grass is best planted some time between September and March, when the sand is moist, the months of November, December, January, and February usually being most favorable for transplanting. Two-year-old plants give the best results and are collected either by pulling up with the hand or, when this cannot be done, by using the spade, care being taken to use one or two nodes to each plant. The stock is then transported to the area to be planted, where the labor is usually done by men working in pairs. Plantations are usually made in strip or rectangular form, with the rows of grass at right angles to the prevailing direction of the wind. The holes are usually arranged in quincunx form, from 12 to 18 inches apart each way. One man prepares the hole by inserting a spade with a long, straight, heavy blade into the wet sand and pressing it to one side. The second man puts three or four plants in the V-shaped hole, and the first man now inserts the spade just back of the bunch and pushes the sand up tightly against the grass, thus completing the operation.

Another method, where one man is working alone, is for him to use an ordinary shovel, digging holes in the wet sand, and when a number

of these have been dug to place the plants in the holes in bunches and fill in the sand removed by the spade with his hands, tramping down with the feet afterward if necessary.

A third method, and one used somewhat in northern California, is to plow a furrow, with the use of a team, and then plant in this by hand, using the feet to tramp the sand down and firm it around the plants.

The cost of planting varies somewhat with the cost of labor and the distance from the source of beach grass supply. On the coast of France some plantations were made for from $16 to $30 per acre. In parts of this country the cost varies from $30 to $60.

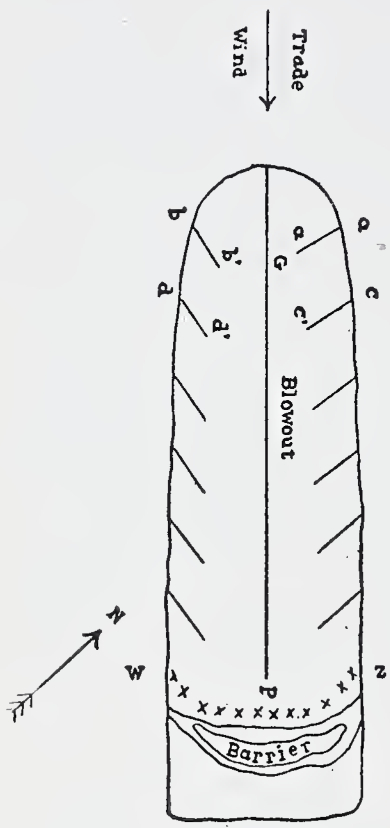


FIG. 2

METHODS USED IN IMPROVING OR RECLAIMING LANDS INUNDATED BY SAND

In places where sand inundation of good agricultural lands has occurred it becomes a problem to know what may be done to prevent further damage and, if possible, improve the condition of denudation. Hundreds of acres of good meadow-land have been covered up and rendered worthless by sand encroachment. The encroachment has usually been in the form of long strips, from 10 to 300 feet wide, spreading out over the meadows at a typical depth of 2 feet and constantly tending to spread out laterally with each shift of wind, as well as shifting along in the direction of the trade-wind.

Approaching the problem with the hypothesis that the same wind velocity that shifted the sand onto the area could be used to sweep the sand off from the good land and stack it in suitable places, protected from further shift, it is then believed that a new system of reclamation was devised Commencing at the source of the drift, all further encroachment was prevented, using the ordinary methods of reclamation. Then a place was selected near the head of the drift where the wind was strong and the sand shifting, on which beach grass, brush, or fencing was planted on the lateral margins at intervals, preventing the spread there and leaving the central portion to shift (fig. 2). The obstructions on the lateral margins were not placed at right angles to the prevailing direction of the wind, which is the usual rule for barrier formation, but were slanted as aa′ and bb′, etc. This caused the wind, striking at a and b, to be deflected toward a′ and b′, scurrying the sand

inward along the base of the obstruction and greatly increasing the velocity of the wind at G. What is known as a blow-out was then formed along the line GP, the sand moving with amazing rapidity toward the final fence obstruction WZ, behind which it was heaped up and then fixed by plantations of beach grass. When the wind swept up all the sand at G down to the surface of the good agricultural soil, then the grass or brush at aa′ and bb′ was removed gradually from a′ and b′, and the obstruction at cc′ and dd′ deflected the intervening sand toward the blow-out. The land at aa′ and bb′ is then reseeded and used for grazing. This process is continued until all the sand has been swept up and accumulated at WZ, thus exposing the inundated agricultural soil again and making it available for use.

Where it is desirable to reduce the accumulation of sand at one place and shift it to another position to be fixed, stock may be run upon the area, and by the stirring given the sand by their feet they will materially assist in hurrying the sand away.

EXPERIMENTS WITH TREES

So far most of the experiments conducted in the reforestation of sandy lands on the area have been made in order to determine what species would thrive best and how the trees could be most successfully treated without any attention during the summer months and still survive the trying conditions. Very little attention was given to protecting young stock from frost and no cultivation was used after planting.

Experiments were early conducted with Sitka spruce, lodgepole pine, hemlock, and Port Orford cedar, obtained from neighboring woods, which were planted out during the late fall on both shifting sand and on sandy areas reseeded to grass. This experiment was almost a total failure, most of the plants dying when planted during the late fall or in the following summer, and indicated that direct planting from wild stock grown on the sand was not satisfactory. Further, the slow rate of growth of the survivors from this plantation indicated that these species are not peculiarly adapted to sandy-land plantation. One of the lodgepole pines, planted 14 years ago, is only 3 feet in height, while trees of species which have demonstrated their suitability for this kind of forestation, planted at the same time, are now from 12 to 15 feet high.

In 1884 some blue gums (*Eucalyptus globulus*) were set out on sandy drift soil, protected when young by fencing, and watered during the first summer season. Most of these grew, and today 13 of them, varying in height from 20 to 40 feet, and in diameter from 10 to 24 inches, form an excellent shelter for stock and buildings against the heavy northwest

wind. The trees most exposed to the fierce trade-winds have their branches somewhat bent and burned, but the crown of the tree continues to increase in height and breadth on the south side, thus deflecting the wind upwards and affording some protection to the next tree south of it, allowing this to grow still higher. It is probable, should a whole block of these trees be planted, that the trees protected on the northwest by the first four or five rows would attain a much greater height and have a more symmetrically shaped crown and bole.

Two other groves and a few scattering individuals of this species are found on other soils in the county.

It is interesting to note that in this heavily timbered region the eucalyptus is taken in preference to any of the native species for piling. The superintendent of the Crescent City wharf has used them successfully, and states that they are much superior to Douglas fir for this purpose, outlasting the latter two or three times over and almost equalling the fir, set in concrete to keep the marine insects from boring.

It can be safely said that the blue gum, after passing its young and tender stage, will withstand any cold which the Del Norte County coast climate has had since 1884, and that it makes a growth more rapid than any native species, is valuable as a wind-break and also for piling.

In 1899, 1900, and 1901 Monterey cypress, acacia longifolia, and tree mallow were planted on sandy hills partially seeded down to grass. The cypress and acacias were one-year-old nursery transplants. Nearly all of these lived and now are from 10 to 15 feet high, very bushy, and excellent for shelter. If they had been planted closely together, undoubtedly greater height growth would have been obtained. Several other small plantations were made in years following of the same species and of cytis, Lombardy poplar, weeping willow, etc.; but all were failures, due to lack of protection from stock, carelessness in planting, and to excessive drying out of the soil during the first summer, before the roots got down deep into the soil.

In the fall of 1912 over 500 small plants of Monterey cypress, acacia longifolia, Lombardy poplar, weeping willow, blue gum, and leptospernum were shipped by steamer and hauled by team to the area, and after being heeled in for a month were set out in sandy soil. The acacias and leptospernum were yearling transplanted nursery stock, and the cypress and eucalyptus were naturally reseeded stock transplanted for two months. To obviate the excessive drying out which sandy soils undergo during the summer, about 20 per cent of the holes were filled for a depth of 12 inches with an alluvial river-wash deposit and about 40 per cent with coral dust mixed with sand; the remaining 60 per cent of the soil varied

from pure coarse drift sand down to sandy meadow soil containing a good deal of humus. In addition to these trees, 50 small native willows were dug up and transplanted. All these were last seen near the end of July, 1913, and upon count 40 per cent were found to be living. A large part of the loss, no doubt, was due to mechanical injury and excessive drying out during a long steamer trip; but lack of cultivation to keep down the grass in the meadow soils, lack of moisture during the months of June and July on the higher drift soils, and frosting of acacias and eucalyptus during the unusually cold weather last winter, no doubt, were contributing causes to death. More can be determined concerning the success of this experiment by next year, but it is not too early to state that more trees survived when planted in holes containing river-wash soil. Next came those planted in holes containing coral dust; then came those planted in coarse dune sand, which seemed to form a mulch. The greatest loss occurred where trees were planted on high sand ridges, which had become fixed for a long period, and in the meadows, where many kinds of grasses, sedges, and rushes grow so rapidly from the sides that the hole was filled up with their roots, and the slower-growing young tree lost out in the competition for space. In general, the Monterey cypress seemed to survive the unfavorable conditions better than the other species, but the acacias and eucalyptus grew more rapidly. With older plantations this was quite uniformly so up to the time when the cypress roots reached the ground water, and then they grew more rapidly than the acacias. This usually occurred at the age of 10 years on the area described.

Other tree plantations were made in the fall of 1913, including another species of eucalyptus (*E. viminalis*), which gives promise of success in this locality.

COMPARISON OF CONDITIONS

Conditions of the sand-dune region on the Siuslaw Forest are in many respects similar to those in Del Norte County, California.

Samples of sand, when examined under the microscope and compared, show much similarity of form and composition, the particles being smoothed and rounded as a result of much water action in both instances and displaying a great variety of color. Samples examined from Cape May, and particularly from Cape Cod, have their grains composed almost entirely of colorless quartz, and we should therefore expect the latter to be more sterile in composition. It is expected that all sands show a deficiency in all the ingredients necessary to plant life; but samples of dune sand from Del Norte, given the short analysis, showed a little lime and

humus to be present and about 2 per cent of phosphoric acid, which latter is very good for sand, being about one-third the amount found in good agricultural soils. The sand coming from the mouth of the Umpqua River is finer grained than the average dune sand from Del Norte County, having 100 per cent of its composition less than one-half millimeter in size, as against 93 per cent for the latter.

The native vegetation as enumerated in Munger's "Silvical Reconnaissance of the Sand-dune Region of the Siuslaw National Forest" consists of: Trees—lodgepole pine, Sitka spruce, and Douglas fir; undergrowth—salal and blueberry; herbs—peavine, umbelliferarea, wild strawberry, kinnikinic, tansy, and equiseta. All of these and many others besides grow on the sand-dunes of Del Norte County, with the exception of peavine, which in that locality is found in the lower sandy lands and swales. Among the additional plants growing on this sand-dune area are hemlock, lowland fir, willows, crab-apple, undergrowth of brakes, salal, huckleberry and blackberry vines, and herbs consisting of many varieties of native grasses, sedges, rushes, clovers, a variety of lotus, yellow sand verbena, shore morning-glory, purple lupine, sand burr, and everlasting.

The climates are also much alike, being modified by the same ocean currents, which prevent extremes of temperature and induce a heavy precipitation, all of which considerations are important as affecting the possibility of growing the same species of introduced plants in both localities. The average precipitation at Crescent City for 21 years is 69.41 inches, and for Gardiner, Oregon, for 19 years, 79.31 inches. The mean annual temperature for Crescent City, California, is 51.5 degrees, and for Gardiner, Oregon, 52.5 degrees. Below is given the absolute minimum and maximum temperatures by months for several places in northern California and Oregon for the sake of comparison as to their relative adaptability for the propagation of plants having peculiar temperature requirements:

Month.	Portland, 35 years.		Grants Pass, 19 years		Gardiner, 19 years.		Crescent City, 11 years.		Red Bluff.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
January	—2	62	0	71	20	67	28	70	18	77
February	7	68	10	75	16	75	23	69	23	82
March	20	79	18	83	26	82	29	80	25	86
April	28	90	21	94	30	93	30	82	31	96
May	32	99	24	98	31	86	33	85	35	110
June	39	99	32	104	32	101	34	81	41	110
July	43	102	35	110	40	102	39	100	48	114
August	43	97	33	107	41	89	34	76	52	114
September	35	93	24	103	34	93	33	83	43	107
October	31	83	20	93	35	87	32	87	35	97
November	11	73	12	75	21	73	31	77	28	88
December	3	65	15	67	27	69	27	66	24	79

From this table it will be seen that the minimum temperatures at Gardiner are slightly lower, and the maximum temperatures slightly higher than at Crescent City, but in the main not much difference exists between the two places. At Grants Pass the extremes of hot and cold are much greater, and yet the frost-sensitive eucalyptus is found growing there. At Red Bluff, California, the minimum temperatures are almost as low as at Gardiner, and are accompanied by much higher maximum temperatures during both winter and summer. The former are apt to be much more serious to cold-sensitive trees when preceding cold weather, and still blue-gum trees are found growing at Red Bluff. For the sake of comparison, it will be seen that the temperature at Portland occasionally goes down below zero during the winter; therefore it is believed that blue gum could not survive even for a short period there, and it is not likely that even the hardier species of eucalyptus of commercial importance could live for any great length of time in that locality.

The average date of the first killing frost at Crescent City is November 27 and at Gardiner December 8. The average date of the last killing frost at Crescent City is May 10 and at Gardiner March 27. So in this respect Gardiner is more favored than Crescent City.

The yield possible from plantations of eucalyptus and some acacias on sandy dunes is so much greater than that which can be obtained through the planting of any native or European species of tree that it is well worth while to consider their propagation on both areas. Below is given a table indicating the minimum temperature which mature trees of various species of hardy eucalyptus will bear, taken mainly from McClatche's work on eucalyptus, after consultation with other works and persons having experience on the subject:

Name.	Minimum temperature (degrees).	Name.	Minimum temperature (degrees).
E. amigdalina	3	E. Gunnii	3 to 20
E. eugenoides	3 to 20	E. leucoxylon	15 to 20
E. obliqua	14 to 20	E. rostrata	15 to 20
E. rudis	15 to 18	E. stuartiana	10 to 18
E. viminalis	3 to 20		

All the species enumerated above grow well in a coast climate and are supposed to be able to endure more cold than *E. globulus.* and therefore would be likely to thrive at both Crescent City and on the coast south of the Siuslaw River. It must be borne in mind that in the cool coast climate, where extremes of temperature are not found, plants sensitive

to cold will endure a lower temperature than in the interior. It is not at all unlikely that some other species of eucalyptus could be grown on the southwest coast of Oregon, and a new limit of absolute minimum temperature at which these species are supposed to grow could be established under the favorable conditions present. However this may be, all the species enumerated in the table have withstood lower temperatures than the lowest which has been recorded at Gardiner for the past 19 years. Blue-gum eucalyptus is, according to a number of publications, not able to stand less than 17 degrees, but it has endured less than this at Grants Pass, Oregon; and, although its introduction into Oregon must be entirely experimental, it is believed that after the first few years of growth it would thrive on the sands of the Siuslaw, for only during one month has the temperature registered less than 17, and that was only by 1 degree.

Because of the rapid growth and greater yield per acre, experimentation with the more rapid growing and valuable of the eucalypts enumerated in the table is recommended for the Siuslaw area. It is not claimed that the yield of eucalyptus on poor sandy lands and in the cool coast climate will be as great as yields obtained from good soils in warmer climates, and it is not thought that the outer rows of trees, planted next the coast and exposed to the fierce northwest gales, will ever be of much commercial value; but when planted in blocks, trees of more perfect development can be obtained. Below is a table of yields from eucalyptus plantations on poor sandy beach lands at the Presidio, San Francisco, taken from "A Handbook for Eucalyptus Planters," by G. B. Lull:

Plot.	A	B	C	D	E	F
Age in years	10	13	13	13	13	13
Area measured, acres	0.2	0.5	0.5	0.5	0.6	0.4
Original spacing, feet	4x4	5x5	8x4	7x8	8x8	8x8
Stand per acre, trees	2315	1166	888	638	565	505
Average diameter, inches	3.9	5.2	5.4	5.7	6.1	5.5
Maximum diameter, inches	7.	11.	12.	10.	10.	11.
Average height, feet	24.	47.	52.	56.	51.	44.
Maximum height, feet	31.	59.	64.	86.	67.	72.
Yield per acre, cubic feet	2309.9	3103.8	2658.	2657.6	2296.8	1592.
Yield per acre, cords	25.7	34.5	29.5	29.5	25.5	17.7
Yield per acre, board feet	....	1710.	1100.	2510.	2363.	1563.
Yield per acre, av. ann., cords	2.6	2.7	2.3	2.3	2.0	1.4

Comparing the yields tabulated above with the yields of Douglas fir on quality No. 1 soils, western foothills of the Cascade Mountains, in Washington and Oregon, Table 4, page 18, of Forest Service Circular

175, by T. T. Munger, it will be seen that the yield in cubic feet per acre is about twice as great for blue gum from 10 to 13 years old. This is a remarkable showing for trees grown on poor sandy wastes, and no better results could be wished for if desired for fixation purposes alone; but it is not likely that this tremendous lead over all native species and on all classes of soil could be maintained indefinitely. Superintendent McLaren has noted some slowing up of growth of eucalypts after the age of 10 years on sand-dune lands at Golden Gate Park. The trees get what he calls "bark bound," and his remedy is to scatter street sweepings to enrich the soil.

The acacias constitute another group of frost-sensitive trees, some of whose members make rapid and valuable growth on dune lands. T. Smith, writing from New Zealand, states that the black, golden, and silver acacias stand from 8 to 10 degrees of frost. J. B. Davey states that they thrive in a winter temperature ranging from 40 to 50 degrees; in fact, a little above the freezing point is sufficient. Large specimens of *Acacia decurrens dealbata* are found growing in northern California at Smith River and Red Bluff. From these facts, together with the record of temperature given before for Gardiner, it seemed likely that these varieties would thrive on the sands of the Siuslaw. Some of the acacias are extremely valuable for their tannins, having a higher percentage of this material in their bark than any of our native species, and it might be possible, by starting their propagation on otherwise unprofitable waste land, to establish a new and permanent industry on the Forest. Black wattle (*Acacia decurrems var. mollis*), silver wattle (*Acacia decurrens var. dealbata*), and golden wattle (*Acacia pycnantha*) are all used commercially for tannin, both in Australia and in England. The two former are also rapid in growth. *Acacia longifolia,* although a small tree, has proven itself to be particularly well adapted to growth in shifting sand, both in its native country and on the Pacific coast of America, where its growth is very rapid for the first ten years. Its bark is also of some value for tannin extract; and, after its tender youth, the tree would probably thrive on the Siuslaw sands.

Trees of other genera discussed in this report need no protection from cold. Although not producing a wood which is of much value, Monterey cypress, because of other qualities, deserves special mention. It thrives well on sandy lands and under the most trying climatic conditions on the coast, forming a dense permanent wind-break behind which more valuable but less sturdy species can find protection from the wind.

RECOMMENDATIONS

If it is concluded that the present or the future reclamation of the sand-dune area, or portions of it, on the Siuslaw Forest is to be carried out, the following measures should be taken:

(1) All cattle, horses, or other grazing animals should be excluded from the area where any damage can be done by their presence.

(2) All vegetation should be protected from fire.

(3) An investigation should be made of the area to determine the location of the most important parts to be reclaimed. It probably would not pay at this time to reclaim the whole area, but if it is evident that the shifting of sand is impeding navigation by filling in harbors or channels of navigable streams, or where the inundation of valuable lands, forests, or other property is impending, a start toward reclamation should be made without delay.

(4) The desirability of starting early experimentation, particularly with the beach-grass planting, should not be overlooked, because the grass spreads from year to year, both by seed and underground stalks, thus eventually saving a good deal of labor in artificial planting. Enough beach grass growing on the area should be secured to serve as a nucleus from which future plants could be secured without the expense of transportation from a distance. Stands of the grass should be secured in the vicinity of the location of the future barrier dune, and these could be placed at intervals of one-quarter to one-half mile apart to avoid the labor of transportation when extensive reclamation is undertaken. The surest and most satisfactory way is that of setting out the plants; but if a supply of these cannot be obtained, areas could be seeded and then covered with brush to prevent the sand and seed from blowing away.

(5) Experiments should be made with some of the trees successfully grown in Del Norte County, as well as rapid growing native and exotic species which give promise of success. In order to insure results, a small nursery should be established at or near the area in which to grow the more delicate species before finally setting out. The planting and seeding of the following species, which thrived in Del Norte County, should be made: Monterey cypress (*Cupressus macrocarpa*), blue gum (*Eucalyptus globulus*), and acacia longifolia. Experimental propagation of the following, which have succeeded well on sandy lands elsewhere, should be made: Monterey pine, maritime pine, Scotch pine, acacia decurrens dealbata, acacia decurrens mollis, acacia pycnantha, acacia saligna, eucalyptus amigdalina, eucalyptus eugenoides, eucalyptus obliqua, eucalyptus rudis, eucalyptus viminalis, eucalyptus rostrata, eucalyptus stuartiana,

and the more rapid growing and useful varieties of willow and poplar for the lower places. In the case of the acacias and eucalyptus care should be taken to protect the young plants in the nursery before setting out until it is learned by actual experience what degree of frost the young of the various species will stand in that locality; and the trees, when set out, should be of much larger size than that commonly used.

The absolute temperature at which acacias and eucalypts can be grown is not an easy matter to determine. Hardly any two authorities will agree upon this point when their observations have been made in different countries or in different sections of the same country. During the unusual cold wave of last winter sections of country in southern California commonly supposed by writers on eucalyptus to be entirely suitable for the propagation of eucalyptus had young plantations of that tree very badly damaged; whereas plantations 700 miles north of this, in Del Norte County, supposed by some to be entirely out of range of eucalyptus growing, suffered no injury from frost. The conclusion is that a definite local, rather than regional, knowledge of the conditions existing over a period of years must be obtained for each place before a valuable opinion can be entertained as to probable success of propagation, and it is believed that the only sure test of this matter is to have, in addition to the foregoing, an experience with the propagation of the tree itself over a period of years in the locality.

SUMMARY

(1) Large areas of drifting sand exist along the coast of northern California and southern Oregon, most of which are owned privately; but some in the latter place constitute a portion of the Siuslaw National Forest.

(2) Very little attempt to reclaim these areas has been made, except in the region a little south of Lake Tallawa and extending north to the mouth of the Smith River, Del Norte County, California, in which locality extensive reclamation has been undertaken by the ranchers, and in parts a definite system developed that has proved itself to be successful.

(3) The system makes use of some of the European methods of reclamation, with other features added to meet the local requirements. It makes use of board fencing, brush, and plantations of beach grass to stop the progress of the sand and secure its fixation. Reclamation usually starts with the formation of the barrier dune, upon which the sand rapidly accumulates, and after fixation is accomplished this is useful not only in stopping the further progress of the sand, but serves as a valuable wind-break for stock, agricultural lands, and tree plantations.

(4) The plant which has proved itself to be best adapted to sand-dune reclamation is beach grass (*Ammophila arenaria*). This grass is planted during the winter season in strip or rectangular form, the rows running at right angles to the prevailing direction of the wind, and the holes spaced from 12 to 18 inches apart, according to the location and purposes desired. Aside from its value as a sand-dune fixer, this grass, by chemical analysis and experience with stock, has demonstrated its grazing value.

(5) Experiments on the area described were made with the propagation of various tree species. Planting usually took place during the fall in order to get the trees started before the dry and windy summers. Excessive drying out during the first summer following planting was responsible for the death of the greatest number of trees. The highest percentage of survival was obtained when the trees were watered during the first summer and when hardy nursery transplant stock was used. Better results were obtained when the trees were set in holes filled with riverwash soil or coral dust rather than in the pure sand. Least success was obtained where wild stock was used, and when the trees were placed on high and dry dunes fixed for a long period, or on heavily sodded sandy meadow soil with no cultivation. The native species tried proved too slow of growth. Best results were obtained from blue gum, Monterey cypress, and acacia longifolia.

(6) By a comparison of soil, climate, and native vegetation, it was determined that conditions on the area studied and the sand-dunes of the Siuslaw Forest, in Oregon, are quite similar. This leads to the opinion that most of the introduced trees growing on the sand-dunes of Del Norte County could be grown on the Siuslaw sands, and it is believed that some of the hardier varieties of acacia and eucalyptus could be grown there likewise if care is taken with the propagation of the young trees of these genera.

(7) Where it is desirable to further the reclamation of the sand-dunes on the Siuslaw area, it is recommended to exclude all grazing, to protect the vegetation from fire, to determine the area where reclamation is needed most, and start small areas of beach grass there, which after increase may be used in extensive reclamation, and finally to experiment with the propagation of various sand-loving tree species, among which are several varieties of acacia and eucalyptus, from which greater yields are obtainable in a short time than from any native or European species of tree.

READING AND REPLOTTING CURVES BY THE STRIP METHOD

BY W. B. BARROWS

Contributed

It becomes necessary in many cases to harmonize curves which represent graphically values used in forest measurements—that is, to read and replot a set of curves in order to "iron out" the irregularities. The ordinary method of doing this is merely to read the curves, putting down the values on paper and later to plot these points on another piece of cross-section paper. It is the purpose of this article to show how this can be done more accurately, more quickly, and with less labor.

A strip of paper an inch to an inch and a half wide and a little longer than the greatest value to be read is used. This strip should have one straight edge, which is kept on the right-hand side. (It could, of course, be kept on the left side and the corresponding changes in procedure made. However, in this case it will be assumed for the sake of uniformity that the straight edge is on the right.) If the lower left-hand corner of the strip is folded along the dotted line (fig. 1), so that it comes up at right angles to the rest, it will be found to serve as a convenient handle for moving the strip about. In the case of long strips it may be desirable to turn up the upper right-hand corner also.

Assuming that the cross-section paper is placed squarely before the operator (fig. 2), the strip is laid along one of the ordinates, its straight edge coinciding with the ordinate to be read and its lower right-hand corner at the intersection of the ordinate with the X-axis or zero line. The point where each curve intersects the right-hand edge of the strip is then marked and numbered. Suppose, for example, that the sheet represents a volume table based on diameter and height; that the lowest curve represents values for 40-foot trees; the next 50-foot, and so on, the last giving values for 100-foot trees. The 40, 50, and 60 foot curves begin on 8 inches, so that after being marked for 8-inch trees the strip appears as in figure 1. If the ciphers are omitted, the strip can be marked as in figure 3.

A still further saving can be made by making the mark and number all in one stroke, although in this case it is desirable to modify the figures somewhat. A set of abbreviations of this kind which has been found satisfactory is shown in figure 4. When it happens that a curve inter-

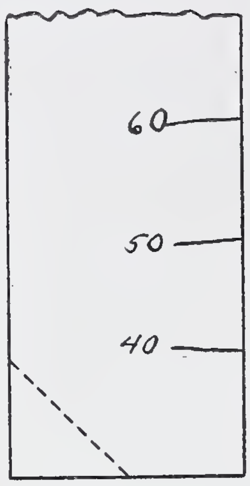


Fig. 1

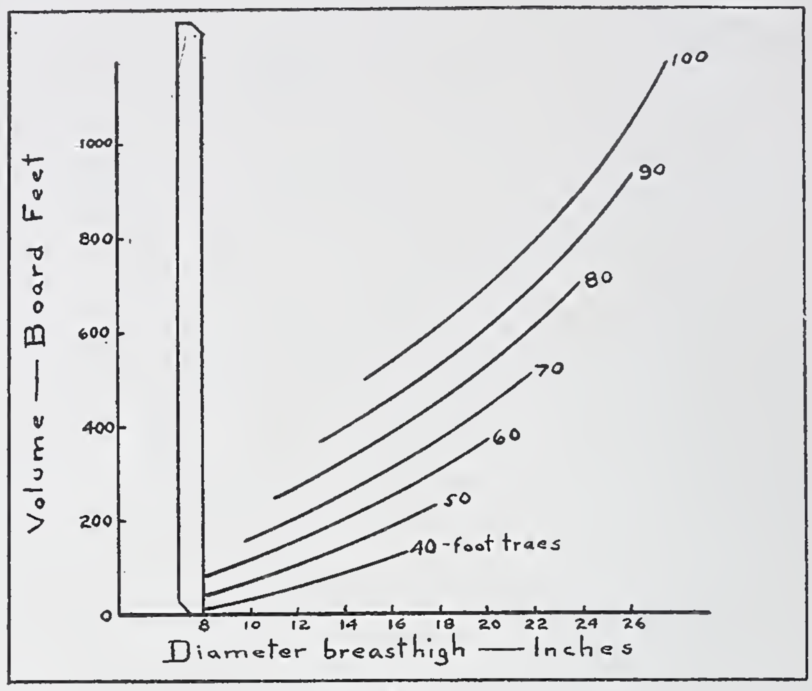


Fig. 2

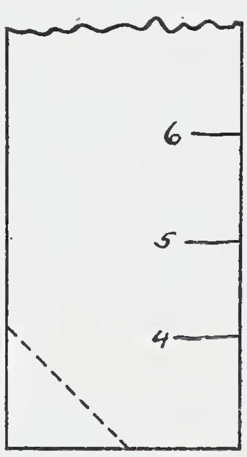


Fig. 3

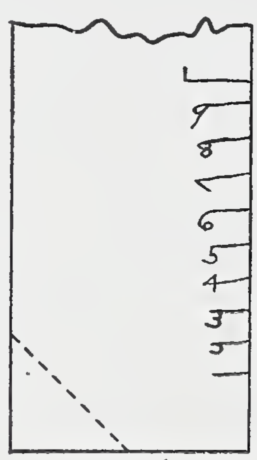


Fig. 4

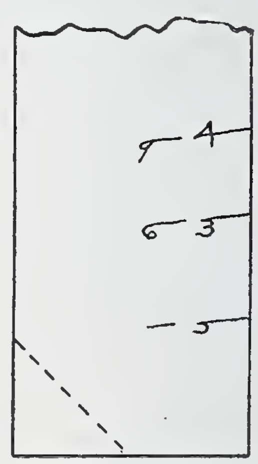


Fig. 5

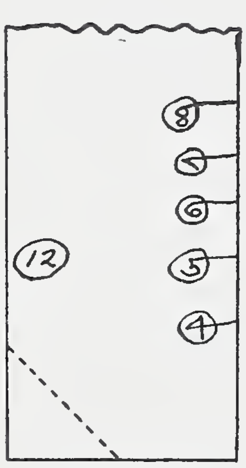


Fig. 6

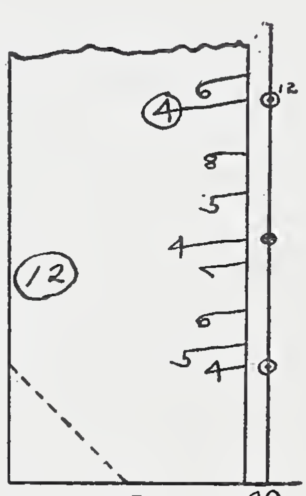


Fig. 7

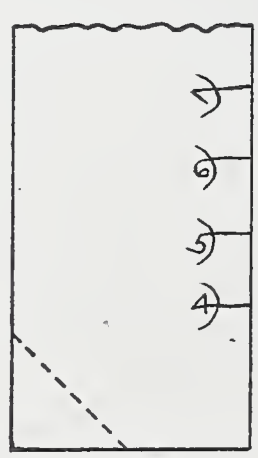


Fig. 8

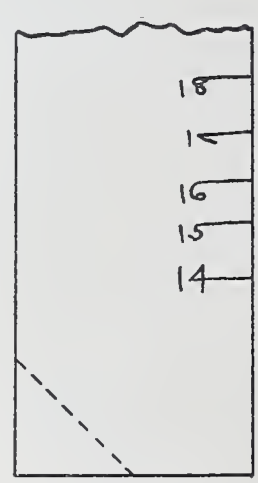


Fig. 9

sects the strip at a point where there is already a mark, the second mark and figure are put at the left of the first, as shown in figure 5. The strip is then moved to the 10-inch ordinate and the points where the curves intersect the edge of the strip are marked as before. This process is continued until all the even diameters (8, 10, 12, 14, etc.) are represented on the strip. If the space on the strip is overcrowded, the odd diameters should be put on another strip, but if not they can all be put on the same one. The lowest diameter for which there is a value on the 100-foot curve should be kept in mind, and when the intersections along this line are marked, a circle should be drawn around each in order that this diameter may be identified (fig. 6). A small circle should be drawn near the left edge of the strip and the diameter written inside it, as in figure 7. In case this diameter is not represented in all the height curves, an additional diameter can be used as identifier. The lowest diameter of the highest curve does very well for this purpose.

The reading has now been finished and the plotting is ready to be done. The strip is placed on the paper on which the second set of curves is to be drawn, so that it lies parallel with the 40-foot ordinate and about one-tenth of an inch to the left of it. The lower right-hand corner is on the X-axis or zero line. Then opposite each mark which is numbered 4 put a dot on the 40-ordinate and put a little circle around the dot to make it more conspicuous. The mark on the strip which has a circle around it should be numbered to correspond, as shown in figure 7. This is continued until all the points are plotted. Since each ordinate will have at least one point which is labeled, it will be a simple matter to label the rest of the points, or enough of them to make it possible to draw the curves without confusion.

The process can now be repeated, using a number for each diameter instead of one for each height. It often happens that there are more than ten curves to mark onto one strip. If the numbers were repeated confusion would result. It is possible to avoid this by several methods. One is to put a half parenthesis around the number, as shown in figure 8, as soon as the numbers begin to repeat. Another is to put a "1" before each (fig. 9). Still another is to use the letters a, b, c, d, etc.

This method gives greater accuracy than is ordinarily obtained, because instead of reading to the nearest unit, which always involves more or less rounding off, the value is read as close as the width of a pencil line. It saves time and effort, because instead of having to concentrate on reading values on a scale which may or may not be convenient, one is able to make the work largely a mechanical process. Where there are many values to be read the saving is no small one.

MONTEREY PINE

BY LOUIS T. LARSEN

Contributed

INTRODUCTION

Monterey pine is of little commercial importance in California, either where growing naturally or where planted, but it is very valuable as an ornamental tree. The principal use of the wood is for fuel, and even for this purpose it is not prized very highly. The wood burns quickly and furnishes intense heat.

The wood is light, soft, brittle, and coarse-grained. It is of a flinty character, which makes it difficult to saw. The greatest objection to the lumber, however, is its knottiness. Large limbs occur every few feet on the trunk of the tree, which leave large knots, making it suitable for coarse lumber only. In the early days it was used for flooring, wharf planking, and bridge construction; but at present, because of the accessibility of better timber, only a very small amount is cut into lumber, and this is used locally for rough construction and for fencing. The lumber twists and warps, but is fairly durable when not in contact with the soil.

Monterey pine is well adapted to sandy soils along the coast and forms a good cover within a short time. Its symmetrical form and deep green foliage make it an excellent tree for ornamental planting. While it is planted extensively for windbreaks and is very useful for this purpose, still the trees on the windward side develop very poorly and have few branches on the side exposed to the wind. Monterey cypress, on the other hand, furnish a denser windbreak and the trees on the windward side develop symmetrically.

RANGE AND OCCURRENCE [1]

The range of Monterey pine is very limited. It is found along the coast south of San Francisco Bay, extending for a distance of 130 miles. It is not even continuous, within this range the localities of occurrence being few and widely separated. It occurs at Pescadero, Monterey, and San Simeon Bay. The heaviest stands are found in the neighborhood of Monterey, where it extends six to seven miles inland. The variety Binata (Lemmon) occurs on the neighboring islands and on Guadeloupe Island,

[1] "The Silva of California," by Willis Linn Jepson.

off the Lower California coast, at elevations of from 2,000 to 4,000 feet. On the islands it is usually either shrublike or not more than 70 feet in height.

CLIMATE

The region in which this species is native is characterized by a mild climate, the temperature ranging from 25° to 95° F. The precipitation varies from 15 to 20 inches and is wholly in the form of rain. Where Monterey pine occurs naturally it is within the fog belt and receives an abundance of atmospheric moisture. On an average, one third of the days are foggy.

ASSOCIATED SPECIES

The Monterey pine forms pure stands in the Del Monte Forest, and this is the largest occurrence of this species. This forest covers an area of about 6,000 acres. Within its boundaries are several small tracts of cypress and Bishop pine. Monterey cypress covers an area of about 40 acres right along the coast, and Gowan cypress an area of about 5 acres in a basin several miles inland. In this same basin there is a large area covered with Bishop pine which came in after a severe fire about 15 years ago. Monterey pine mingles with all of these species on these isolated areas and is gradually crowding out the cypress.

HABIT

Form of Tree

This tree is usually very limby and tapers rapidly. The branches become very large and have an unusual spread, forming a somewhat irregular-topped tree.

When growing in dense stands the trees are fuller-boled and the trunk is cleaner, but even under these conditions they are quite limby. The dense stands of second growth of Monterey pine resemble to a large extent second-growth yellow pine, but the trees are much shorter.

The following table, based on 60 measurements, shows the approximate total height on the basis of the diameter:

D. B. H.	Height.	D. B. H.	Height.	D. B. H.	Height.
2	16.5	14	71.0	26	92.5
4	28.0	16	77.0	28	94.4
6	38.5	18	81.7	30	96.0
8	47.5	20	85.0	32	97.5
10	56.0	22	87.8	34	98.8
12	64.0	24	90.3	36	99.8

ROOT SYSTEM

Monterey pine had no well-developed tap root except in the early stages of its life, but the lateral root system is very extensive. The roots of mature trees are very large and extend from 30 to 40 feet from the tree. Whenever the soil is of fair depth the tree is very wind-firm.

DIMENSIONS OF MATURE TREES

Mature trees run from 20 to 30 inches in diameter and 80 to 100 feet in height. The maximum tree measured was 58 inches in diameter and 88 feet in height, while the tallest tree was 116 feet in height and 42 inches in diameter. In the vicinity of Monterey the majority of the trees are below 24 inches in diameter.

SOIL AND MOISTURE

Monterey pine is not exacting in its soil requirements. It was found growing in all situations, from the best to the poorest. Where it was found growing with Bishop pine in the Del Monte Forest, the soil was a shallow sandy clay which baked considerably during the summer. Naturally very poor growth was made on this site.

It seems to prefer a soil of good depth, although it does fairly well where the soil is not more than three feet in depth. Generally it grows on any soil which is fairly deep and in which there is good drainage, but it prefers a sandy loam.

It is certain that this pine requires considerable moisture, especially atmospheric moisture, for it is not able to adapt itself to the interior valleys and is very short-lived there. While it is able to endure the summer droughts it succeeds only where the annual precipitation is 15 inches or more and where there is considerable fog.

TOLERANCE

Monterey pine is quite tolerant, especially in youth, which is clearly shown by the fact that even in dense second-growth stands the limbs and foliage persist for a long time. Seedlings often come up under stands which are fairly dense and when released they recover to a large extent. As the trees become older, however, they become less tolerant, and when mature they have an open crown and require full light. The tolerance of Monterey pine in youth, together with its exceptional reproductive capacity, makes it very aggressive and no other conifer can compete successfully with it. It can stand considerable suppression for a long time,

but in such cases the growth is very slow. Ordinarily it will struggle along in this manner for 30 years or more before it dies.

GROWTH AND LONGEVITY

Rate of Growth

Monterey pine is one of the most rapid-growing pines on the Pacific coast, but growth culminates very early. In a few cases annual rings as wide as an inch were measured, but this is unusual. It reaches normal height within about 50 years, after which the height growth is rather slow.

A number of trees were cut in the Del Monte Forest last spring and this afforded an opportunity to secure about 30 stump analyses. The diameter breast height and the total height of 60 trees were measured and the taper from stump height to breast height recorded. From these data a table was constructed, showing the approximate age of trees of different diameters and the heights corresponding to these diameters. Seedlings analyses gave the true age at the stump. The following table shows the results obtained:

Age.	D. B. H.	Height.	Age.	D. B. H.	Height.
5	2.6	20	45	19.1	84
10	6.2	39	50	20.1	85
15	9.4	53	55	21.0	86
20	12.0	64	60	21.8	87
25	14.2	72	65	22.6	88
30	15.7	76	70	23.3	89
35	17.0	80	75	23.9	90
40	18.1	82	80	24.5	91

The growth along the beach near Pacific Grove was somewhat faster than that indicated in the above table. The soil here is of very good quality and the height of mature trees averaged 105 to 110 feet.

A large plantation was established about 7 years ago on the hills around Berkeley for the purpose of securing a forest cover, and these trees now average 6.7 feet in height, while a few are 10 feet or more. They were planted 16 feet apart, so they are very limby, the limbs extending clear to the ground.

Trees planted for ornamental purposes in Berkeley have made exceptional growth, in some cases reaching a height of 60 to 90 feet within 30 years.

The growth at the Presidio, in San Francisco, has been rather poor. The soil is either a shallow sandy loam or drift sand of poor quality. The trees planted near the beach 23 years ago average about 7 inches in diameter and 32 feet in height. Those planted at the top of the ridge along

the road average about 9 inches in diameter and 55 feet in height. The present age of this stand is 20 years. In both cases the spacing was too close and the competition retarded the growth. In the case of the trees planted in the ravine at the entrance to the grounds, about 30 years ago, the average height is 62 feet and the diameter 17 inches. These trees were planted far apart, so they are very limby and taper rapidly.

The Monterey pine in the Sutro Forest in San Francisco, which was established about 35 years ago, shows very poor growth as a result of suppression. This forest is made up of blue gum, cypress, and pine, and the blue gum now forms an upper story and suppresses all other trees. The larger Monterey pines here average 14 inches in diameter and 65 feet in height.

Where dense stands come in as the result of fires the growth is very slow, due to the competition. On the other hand, where trees grow in the open the growth is exceedingly rapid and the diameters attained are far above the average. Such trees are very limby and the height is much less in proportion to the diameters than in the case of those grown in the forest.

LIFE

This tree is rather short lived. The average life is 80 to 90 years, but occasionally trees reach an age of 150 years or more. In the interior valleys and in southern California it seldom lives more than 20 or 30 years.

YIELD [2]

The trees are usually scattered in the forest and mature stands will average less than 20,000 feet b. m. to the acre, and with normally stocked stands the yield would be very much greater. One stand measured, which was somewhat better than the average, contained about 35,000 feet b. m. to the acre. This stand was about 50 years old. The trees averaged 15.5 inches in diameter and 84 feet in height and there were 165 trees to the acre. The heaviest stand measured in the Del Monte Forest totaled about 120,000 feet b. m. to the acre. In this case there were 195 trees averaging 20.3 inches in diameter and 94 feet in height. This unusually heavy stand was only one-tenth of an acre in extent.

A cutting was made 25 years ago along the beach near Pacific Grove in which all but the small trees were removed. At present the best of these stands will average 43,000 feet b. m. to the acre, which is a growth of more than 2½ cords per acre per year. This, however, is an unusually favor-

[2] Yield computed by Clark's International Rule Volume Tables, using Gallaher's second-growth yellow-pine tables prepared on Tahoe National Forest.

able site for Monterey pine, as is shown by the exceptional height growth made in the locality. The trees on the plot measured averaged 14.1 inches in diameter and 77 feet in height and there were 270 trees to the acre.

SUSCEPTIBILITY TO INJURY

Insects

There are two beetles attacking the Monterey pine—*Ips concinnus* and *Dendroctonus valens*. Both kill the tree, but the greatest damage is done by the Ips. A large number of trees in the Del Monte Forest have been killed by beetles, but they have been cut as soon as they showed signs of disease. Such trees are cut up into cordwood and the refuse piled and burned, so there is very little left for the insects to breed in.

Fungi

A little damage has been done throughout the Del Monte Forest by fungi, but it is not serious. Many young trees and a few older ones are attacked by a parasite fungus which causes round knots or nodules on the young stems and branches. At first the knots are about an inch in diameter, but later sometimes grow as large as a foot or more in size. Such trees are, of course, of no value for timber and they are liable to break off either directly above or below the knot during a heavy wind.

Dr. Meinecke made an examination of the trees on the grounds around Del Monte Hotel and found that a great many of the trees were infected by Trametes and Polyporus. The large amount of infection there was probably due to the damaging of the roots of the trees or to pruning.

Trametes was the most common. It is a cambium-destroying fungus which gains entrance through the roots and it attacks the roots and the lower part of the trunk first.

The Polyporus was found less frequently, but it destroys the heart of the tree and renders the wood worthless. It gets in through the wounds of the trunk and spreads from the trunk to the roots.

REPRODUCTION

Monterey pine is a prolific annual seeder and cones are produced at a very early age. The cones remain closed anywhere from 1 to 10 years, but even then the rate of germination is high, for the seed is of persistent vitality.

Reproduction is coming in plentifully wherever there is an opening and this species is extending itself rapidly. As a result of severe fires years ago, there are young stands so dense that they are almost impenetrable.

The seedlings seem to prefer a moist mineral soil, but numerous seedlings were found in the Del Monte Forest which had come up last spring in places where there was a layer of litter 3 inches deep.

MANAGEMENT

Most of the planting of this species in California has been for windbreak or ornamental purposes. Within the last few years considerable planting has also been done to secure a forest cover along sandy beaches and on steep hillsides. None of these groves were established with the expectation of harvesting a commercial crop at some future time other than cordwood.

Plantations of this species will never be established to produce timber, for the timber is of poor quality. No doubt fair returns could be obtained by growing it for cordwood on situations within the fog belt, but elsewhere the growth is slow and the life of the tree is very short. This is the only product worth considering in connection with this species. The lumber is so knotty that it would even be difficult to secure box material from it and, besides, it would be rather heavy for this purpose.

The largest stand of Monterey pine is found in the Del Monte Forest near Monterey, Cal., and the value here is an esthetic one. Thinnings are made in this forest from time to time to improve the remaining stand, and all dead material is cut out and the material utilized for cordwood. This is sold for $6 a cord, delivered. The profit is very small because of the expense of hauling. (This is the price charged for what is known as the short cord, and consists of 2 tiers of 14-inch wood, 4 feet high and 8 feet long.) Laborers cut the wood on contract for $1.75 a cord, and 80 per cent of the remainder goes to pay the expense of hauling the wood to town.

REVIEWS

Climatic Changes Recorded in Tree Growth [1]

A mass of evidence, some of it of doubtful value and relevance, is presented by Huntington in support of the conclusion that the climate of the earth has changed appreciably during the past few thousand years, and that the change has been of a pulsatory nature. The chief specific instance of these changes is that the southwestern United States and northern Mexico have been growing drier since 1300 B. C., with some wet intervals. This general trend toward aridity and the times of the noticeable pulsations are the same as in similar latitudes in western and central Asia, for which region the author has previously published his conclusions.[2] For evidence of increasing aridity are taken the traces of a former much denser agricultural population in Arizona and New Mexico than could at present raise their food in those States, even by fully developed irrigation works; the lower levels and in some cases the drying up of lakes, and the general trend of the rate of diameter growth on the stumps of *Sequoia washingtonia* in California, after making allowances for the normal decrease due to age and for longevity. The last of these is given the greatest weight. For evidence of marked pulsations which "have a length of centuries, but do not show any regular periodicity," the detailed record of the growth of sequoias is again given first place, but is supplemented by studies of alluvial terraces, by changes in lake levels, and by such information as is available concerning the history and movements of pre-Columbian civilizations in North America.

The strength of the evidence is not in any one of the subjects discussed, but in the great number of the instances where phenomena are capable of explanation by the author's conclusions fully as satisfactorily as by any other theory, and in the skillful manner in which every bit of evidence is correlated to make a homogeneous whole. For example, the fluctuations in the water-levels of the lakes near the city of Mexico may have been due to world-wide climatic pulsations; or, in accordance with Zon's theory, to the destruction of much of the forest to seaward after the Spanish conquest. But when the author shows that periods of marked high water in the lakes agree with periods of rapid growth by trees in

[1] "The Climatic Factor as Illustrated in Arid America," by Prof. Ellsworth Huntington, with contributions by Charles Schuchert, Andrew E. Douglass, and Charles J. Kullmer. Carnegie Institution, Washington, D. C.

[2] "The Pulse of Asia," 1907, and "Palestine and its Transformation," 1911.

California, he adds greatly to the strength of his own explanation. Chief dependence for proof of the climatic pulsations is put in the results of the investigations on the growth of sequoias, for which full data are given. It is this portion of the rather cumbrous volume which will be of chief interest to foresters, not so much for the conclusions reached as for the road to them.

The discussion of the work on the big trees is prefaced with an article by Prof. Andrew E. Douglass, designed to show that the precipitation in past years can be successfully deduced from the width of rings of trees, particularly in dry regions. In this endeavor Professor Douglass is unquestionably successful. The relation of ring widths on cross-sections of *Pinus ponderosa* to the rainfall at Prescott, Arizona, since 1867 is so plain that the computed total annual rainfall, based on tree growth, "has an average accuracy of 82 per cent for individual years," and would be much closer to the observed figures if five-year or even three-year means were used. The details of these computations are rich in suggestiveness for the forester who accepts the data and conclusions. If the normal radial growth on the stumps of mature and veteran western yellow pines near Prescott can be expressed by such a formula as width of ring in any year—total rainfall in that year = 1.250—or by elaborations of this formula, then is it not possible to discover a law for the variation of the last term in accordance with the changes in average total annual precipitation throughout the Southwest, and so avoid costly and laborious growth studies for each locality and elevation for which the normal rainfall can be approximated? Would not the height growth of saplings furnish an even better record of moisture conditions than the radial growth of old trees? Can the factor of minimum precipitation for one or more years prior to successful natural reproduction be definitely determined by a comparison of the rainfall record, based on tree growth, with the ages of even-aged groups of seedlings or saplings? Whether or not the field opened by Professor Douglass is used for solving these specific questions, no doubt can exist of its eventual value to scientific forestry.

Professor Huntington applied the methods developed by Professor Douglass to *Sequoia washingtonia* in California. Measurements were taken on the stumps of 462 trees (11 were subsequently discarded), varying in age on the stump from 250 to 3,210 years. These analyses cannot fail to be of interest and value to foresters who are working in the region where the big tree grows, for so thorough and careful a growth study would be welcome for any commercial species. That the data are recorded by the metric system deserves notice as the first large

scale instance of the kind in forest work in the United States. With some additional figures for height growth for the first few centuries, it should be easy to compute a usable table of volume growth. The study was made as a means to another end, however, and the uncorrected curve of radial growth arranged chronologically shows strong evidence of climatic pulsations. For example, the sharp increase from 11 to 13.7 mm. in growth by decades during the first half of the 14th century, followed by a decrease for the next century and over, would be difficult to explain satisfactorily on any other basis, since the figures are average for hundreds of trees, and the increase is marked in the trees of 21 out of 27 age groups. The correction of the curve for age, for longevity, and for butt flare does not change these pulsatory characteristics, and the comparison of growth with the recorded rainfall in the last fifty years strengthens the assumption that the irregularities in the curve represent changes in the amount of precipitation. When, however, the author tilts portions of the curve, as corrected, to make the general trend conform to changes in the level of the Caspian Sea, and concludes from the tilted curve that the climate of California is becoming more arid, there is need of confirmatory evidence. The failure of the sequoia to reproduce itself successfully during the last five hundred years on the slopes, contrasted with fairly abundant reproduction in the hollows, cannot be considered as a strong point of support, for the curve of radial growth shows that five hundred years have elapsed since the last long period when moisture conditions were presumably excellent.

Both Professor Douglass and Professor Huntington attempt to find proof of climatic cycles in the minor variations of their curves of tree growth and both are partially successful. Emphasis is given to the partial agreement of cycles in the rate of growth with the 11-year cycle of sun-spots, but it is agreed that further study of this complicated subject is necessary. No attempt is made to establish definite causes for the great and prolonged pulsations indicated by the study of the sequoias, although it is plain that pulsations of the sun may be expected to furnish an ultimate cause, acting through the shifting of the tracks of cyclonic storms.

The usefulness and reliability of yield tables and growth studies are not greatly affected even if there is acceptance of the major climatic pulsations indicated by the growth of the sequoias. Their length of centuries and irregular periodicity make them of much less importance than changes in markets and in silvicultural practice. Predictions of the growth of forests for long periods are only approximations, at best, and are avoided whenever possible. The minor fluctuations in growth,

shown to be often coincident with accepted short climatic cycles, are not large (Douglass shows a range of about 0.25 mm. in Arizona yellow pine for the 21-year cycle) and would be eliminated in drawing curves for the growth of trees from seed to merchantable size, even if the data were arranged chronologically. Also the effect of other factors, such as temperature, on tree growth might hide the influence of minor pulsations in precipitation in regions where the normal rainfall exceeds the minimum required for the development of the native species.

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Wild Life Conservation[1]

Every forester should be interested in and closely identified with the conservation of useful wild life. A recent book on wild life by Hornaday is well worth the careful study of every practicing forester. Until comparatively recent times man's food was largely obtained from wild life. With the increase in population and advance in civilization, the conflict between man and economic wild life has become more and more unequal, until now in every country where wild life is not adequately protected it is rapidly disappearing. The rapidly increasing scarcity of economic wild life near the centers of population in Europe during the latter part of the Middle Ages emphasized the necessity for its protection. The feudal lords gained possession of the forests and placed a restriction upon the chase. Even in that day it was realized that not only the game, but the haunts, of wild life, namely, the forest, must be protected. It was this recognition that marked the beginnings of forestry. The development of forestry and the protection and conservation of economic wild life have in Europe gone on together. In the rapid development of forestry in the United States little attention has been given to the conservation of the useful wild life. In Europe a considerable portion of the forester's time is directed toward the problems dealing with the protection and increase of useful birds and mammals and the decrease of undesirable species of wild life. Little or no attention is given to this subject in the United States by the forester, although the wild lands of the country are coming more and more into his keeping.

Our foresters have been largely trained without a real appreciation of the dependence of wild life upon the methods initiated by them in the management of the forest. For the most part, our foresters are un-

[1] Hornaday, W. T.: Wild Life Conservation in Theory and Practice, pp. iv + 240. Yale University Press, New Haven, Conn.

familiar with the breeding habits and food requirements of the various species. So long as our forests remain in primeval condition and so long as burned, cut over, and otherwise denuded lands are left to themselves to become reclothed with vegetation, wild life will find food and shelter. We are entering, however, upon a new era as regards the handling of our woodlands. Our forests are now being mapped and organized for management. The conservation of useful wild life in them depends largely upon the foresters in charge. Its conservation is not attainable by closing them to the chase alone. The providing of suitable breeding retreats and ample food in the management of the forest is of equal or even greater importance.

Dr. Hornaday's book is a clear and convincing argument for the conservation of useful wild life in the United States and was written especially for forest-school students. A course of five lectures was prepared by the author and delivered before the junior and senior classes of the Yale Forest School in 1914. The book is the outcome of these lectures. The author states in his preface:

"It is hoped by those who have made possible this lecture course and this volume that the presentation may arouse other educators in our great institutions of learning to take up their shares of the common burden of conserving our wild life from the destructive forces that so long have been bearing very heavily upon it. Thus far the educators of the country as a class and a mass have not done a hundredth part of their duty toward the wild life of the United States and Alaska. Let him who doubts this very sweeping statement ask the next young university or college graduate that he meets how much he has learned about the practical business of protecting wild life—this highly important branch of zoölogical work. Which is more important: the saving of the pinnated grouse from extermination or studying the embryology of a clutch of grouse eggs?"

The book is excellently printed and well illustrated. The first five of the six chapters are the five lectures as given at Yale. The subjects are as follows:

(1) The extinction and preservation of valuable wild life.

(2) The economic value of our birds.

(3) The legitimate use of game birds and mammals.

(4) Animal pests and their rational treatment.

(5) The duty and the power of the citizen in wild-life preservation.

The last chapter, which deals with private game preserves as factors in conservation, was prepared by C. D. Walcott, Secretary of the Smithsonian Institution. Mr. Walcott, by study and research, with observation, practical experience, keen interest in and sympathy for wild life and its

preservation, is particularly well fitted to write on the subject of this chapter.

The work closes with a bibliography of the more recent works on birds, with special reference to game preserves and the protection and propagation of game.

Dr. Hornaday's style is clear and trenchant. His facts are narrated in convincing manner. In his discussion of the extinction of valuable wild life he says:

"It is desirable and necessary that every person living should know that systematic slaughter will exterminate the most populous wild species on earth, and accomplish that result in a very few years. Let it be remembered for all time that *no wild species of mammal or bird can withstand systematic slaughter for commercial purposes.*

"Eleven species have been totally exterminated in their wild state, and of those all save two—the parrakeet and passenger-pigeon—are wholly extinct. The list is as follows:

Great auk	Carolina parrakeet
Labrador duck	Cuban tricolor macaw
Pallas cormorant	Gosse's macaw
Passenger-pigeon	Yellow-winged green parrot
Eskimo curlew	Purple Guadaloupe macaw

"All of the above became totally extinct in a wild state between 1840 and 1910.

"One other species, the heath-hen or eastern pinnated grouse, the counterpart of the western prairie-chicken, has escaped total extinction only by a very narrow margin. It is so thoroughly extinct locally that to-day it exists only in one locality, on Martha's Vineyard, in eastern Massachusetts, where about two hundred birds are maintained under rigid protection.

"The history of the heath-hen teaches a practical lesson that should be of great value to the grouse and other game-birds of to-day, if the men of to-day only will heed it. It is a lesson on the folly of *waiting too long before giving permanent protection!* This bird formerly inhabited Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. It was the first American game-bird to be brought to the point of extermination by sportsmen."

The author is optimistic as to the future, but points out the necessity for eternal vigilance on the part of the defenders of wild life, who have already accomplished results along the following lines:

"1. Seventy per cent of the killing of non-game-birds has been stopped.

"2. The killing of game has been restricted to open seasons, which have steadily been made shorter.

"3. Long close seasons, usually for five years, have been extended to a very few species threatened with local extinction.

"4. The sale of game has been prohibited in seventeen states.

"5. They have achieved the complete suppression of the importation of wild birds' plumage for millinery, and the equally complete suppression of the use of native birds as hat ornaments.

"6. They have brought about the creation of a really great number of national and state game-preserves and bird refuges.

"7. There has been a partial suppression of the use of extra-deadly firearms in killing birds.

"8. Finally, the army of defense has secured the enactment of a law placing all our 610 species of migratory birds under the protection of the federal government."

In writing of the National Forests, Dr. Hornaday says:

"Look at a map showing the national forest-reserves. Those reserves belong to the people of the nation at large—partly to you and to me. Shall we not exercise our lawful right to stop game slaughter within their borders? Think what such a step would mean to the wild life of the western third of our country and to posterity—to both of which we owe duties that we can not *with honor* neglect or evade."

After epitomizing the results of his many years of observation and investigations showing the rapid decrease in useful wild life, its value and legitimate use, the author makes a strong plea to the public for better wild-life protection. He says:

"Turn we, therefore, to the open-eyed, open-minded general educators and general students, and lay before them the appeal of the wild. Shall all our best wild life be swept away, until nothing remains saves noxious insects, rats and mice? Shall our forests, our orchards, gardens and grain-fields be presented bodily to the insect world? Shall the dignified chase of deer and bear, the wild turkey and ruffed grouse, degenerate, as it has in Italy, to the popping of robins, sparrows and bobolinks? Already our sweethearts and wives are wearing skunk-skin and rabbit-skin fur, where once they wore sable, otter and beaver. We are presenting annually to the insect world about $500,000,000 worth of our valuable products. Does this appeal to the thoughtful mind, or not?

"The facts and figures that I have endeavored to place before you are no figments of a fevered imagination. They are incontestably true. The conclusions to be drawn from them are inexorable. The saving of our wild life is not an academic cause, or an optional study. It is a burning question of the market-basket and the dinner-pail. The great question of to-day is: Will the American people now rise to the occasion, and prosecute this cause to its logical conclusion—the real conservation of our valuable wild life?"

The reviewer believes that the forestry profession in the United States has not as yet adequately realized the intimate relation which should exist between forestry and the preservation of wild life. The practicing

forester has not fully realized the need on his part for study and research and for observation and practical experience in the protection and preservation of wild life. It is believed that Dr. Hornaday's book will stimulate the forestry profession in the United States to a keener interest in wild-life preservation and hasten the day when forest conservation and wild-life conservation will be recognized as the common duty of all foresters.

J. W. Toumey.

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Spectrophotometric Investigations in the Forest [1]

In an article of about 100 pages Dr. Knuchel has given us some new ideas concerning the color composition and the intensity of light in the forest. He has included many diagrams for a visual interpretation of the dozen or more pages of tabular data; and gives, also, a half-tone cut and an explanatory diagram of the instrument he used for the work.

In this review I have included a digest of the literature cited, in order to bring together the many points bearing on the questions involved in one place in our literature.

The weakening of daylight as it passes through the crowns of trees is a phenomenon which is exceedingly important in many questions concerning the forest; but nevertheless there are only a few exact investigations upon the subject, since simple methods of measuring so complex a mixture of rays as sunlight are lacking. The photographer recognizes the great reduction of intensity under trees, especially of the chemically active rays, but in forestry more than the chemical rays must be considered.

The problems to be dealt with may be summed up under three heads:

(*a*) How much daylight is retained by the foliated and the bare crowns of single trees and of whole stands of different species?

(*b*) How does the color composition of the light under crowns compare with that in the open?

(*c*) What influence has the quality and quantity of light in the interior of the stand upon the origin and growth of the ground flora, especially of the natural reproduction?

The first two problems (*a* and *b*) only are included in this report.

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[1] Spektrophotometrische Untersuchungen im Walde, von Dr. Hermann Knuchel. Mitteilungen der Schweizerischen Centralanstalt für das forstliche Versuchswesen, Zürich. XI Band, I Heft, 1914.

In his review of the literature the author brings out the following points:

1. Photographic methods are accurate only when comparing lights of the same color composition; and this is not the case when comparing direct sunlight with diffused daylight. The photometric method gives 3½ times greater results than the photographic in such comparisons.

2. Daylight under forest cover has a different color composition than in the open, and the photographic method measures only the chemically active rays.

3. Open pine stands retain 60 per cent of the chemically active radiation, fir stands 80 per cent, and beech 80 to 90 per cent.

4. Selenium cells, which change their electrical resistance according to intensity of illumination, vary considerably with change of wave-length.

5. The non-absorbed light under the crowns of trees in the stand forms a higher per cent of total daylight than under trees in the open; for example—

Species.	Per cent of non-absorbed light.	
	Under trees in the open.	Under trees in the stand.
Fagus sylvatica	1.2	1.8
Ulmus montana	3.7	4.1
Quercus pedunculata	3.9	11.0
Fraxinus excelsior	8.5	13.6
Betula verrucosa	17.2	25.7

6. Different spectral areas possess different meanings for the life phenomena of plants.

7. By one method (sensitive papers) it was determined that the color composition is not changed under tree crowns unless the intensity drops below 1/80 of daylight. By another method (hand spectroscope), on the other hand, it was shown that the crown cover does exercise a selective absorption, and that the absorption varies with the different species.

8. Many investigations show that different colors, different amounts of carbon dioxide, and different temperatures all affect assimilation; sometimes the one and sometimes the other of these factors will determine the amount of activity.

9. Only a small part of the energy absorbed is used for assimilation; the larger part is used for evaporation of water.

10. The light used by chlorophyll forms in the spectrum seven sharp bands, strongest in red and in blue and weakest in ultra red and in green. The amount and width of the bands vary with the concentration of the chlorophyll solution and with the composition of the light.

11. The primary curves of assimilation and of absorption run parallel part way through the spectrum and reach their maximum between the Frauenhofer lines B and C, in red, then sink toward yellow and green

and reach their minimum in green. Then the curves separate and the absorption curve rises into the dark blue, while the assimilation curve reaches a second smaller maximum at the line F and then falls again. The "primary" assimilation curve is the one obtained when only a single chlorophyll layer is used, which might compare with the outermost layer of chlorophyll in the leaf receiving nearly unaltered daylight. The light, penetrating to the deeper layers, has a different color composition and there the maximum of the curve is in the yellow green.

12. In the invisible spectral areas assimilation is affected by wave-lengths down to 300 $\mu\mu$ in the ultra violet, while in the red and ultra red the activity decreases rapidly to zero.

13. By means of especially made glass filters for red and blue and liquid filters for green, investigators have shown, when excluding heat rays, that equal intensities of red and blue give nearly equal values for assimilation, and green produces assimilation only in small measure, or even might be harmful.

14. Investigators agree that all kinds of rays of the visible spectrum produce assimilation; those, however, of middle refrangibility are of smaller importance.

15. Regarding growth processes of the plant, experience indicates that plants do not develop normally in mono-chromatic light, and that the short wave-lengths are of especial importance.

All of these points lead up to a demand for further investigation of the spectral areas of light. A suitable instrument is the first requisite, and one that can be used in the forest, where the light that has passed through the crown is changed both quantitatively and qualitatively.

Such an instrument the author has used for the report that follows. It consists of a horizontal tube attached to a tripod, somewhat after the manner of a surveying transit. At one end an electric comparison lamp is attached. The light from this lamp passes in the following order through the several parts of the instrument: the lower half of a slit, a collimator lens, a Rochon prism, a Nicols prism, an Amici prism, and then through the telescope eyepiece. The light to be examined is allowed to enter through a vertical tube from directly above and is turned at right angles by a prism located between the lamp and the slit and passes through the upper half of the slit. In this way the ray of light to be measured runs parallel to a ray from the comparison lamp, and spectra from both sources are examined at the same time. The Rochon prism separates the two rays coming from the slit halves, each into two bundles, polarized perpendicularly to each other. The Nicols prism is used to alter the intensity of the rays, and the Amici resolves them into horizontal spectra. Through the eyepiece two of the spectra lying side by side are seen, one from each slit; the other two are extinguished by adjustments. The two visible spectra are polarized in perpendicular planes to each

other. At the eyepiece a Vierordt shutter is attached to extinguish all colors of the spectra except the one desired for examination. Several devices are used to control the comparison lamp, which gets its current from a storage battery, and to insure proper intensities of light for comparison.

Narrow strips only across definite spectral areas were used for all measurements. The following table gives the location of these strips in the spectrum:

Red, at wave-length	652 $\mu\mu$	near the C line.
Yellow, at wave-length	589 $\mu\mu$	near the D line.
Green, at wave-length	520 $\mu\mu$	near the *b* line.
Light blue, at wave-length	472 $\mu\mu$	near the F line.
Dark blue, at wave-length	440 $\mu\mu$	near the G line.

Measurements to the right or the left of these places were not practicable on account of low intensity of the light in the stands, and also because it is weakened by the passage through the many lenses and prisms.

The vertical tube through which the daylight is admitted is arranged so that only diffused light, which passes vertically through the crowns, is examined.

There are many ingenious devices for measuring intensity and overcoming difficulties that cannot be discussed here. Dr. Knuchel recognizes the limits of his instrument and does not claim more for it than seems reasonable. He points out that the vertical tube through which daylight enters the instrument is always the point of an inverted cone of the light that can be investigated. The size of the base of this inverted cone varies with the height of the crowns above the instrument; for example, at 10 meters height this base has considerably less area than at 20 meters. As a result there is probably a disproportionate amount of unchanged light measured, varying with the height of the crown above the instrument.

In measuring light in the open it was found that even on cloudless days zenith light is subject to great variations within a short time. This necessitated caution in selection of days and time of day for observations, and since 60 readings were required every time the instrument was set up for a series of observations, the difficulty of the work becomes apparent.

Most of the errors were traced to the change in brightness of the sky, which was felt so much more with this instrument, since only a small section of the sky was under observation at a time. As already mentioned, only vertically incident diffused light is measured by the instrument, so it becomes necessary to know what relation diffused light bears to the total daylight and of what importance it is to plant life. From the

literature the author has brought together many factors to show these relations. He has gone to considerable length in the discussion and has given many tables and figures, only the conclusions of which are stated here:

1. Short waves, the blue, are strongly diffused in passing through the atmosphere; the long rays, the red, are weakly diffused.
2. Intensity of diffused light decreases with increase of altitude, while that of direct light increases with increase of altitude.
3. In the spectrum of direct light the maximum of intensity moves toward the blue with increase in altitude.
4. Red and ultra-red rays are absorbed least in passing through the atmosphere, and violet and ultra-violet are absorbed most.
5. The distribution of energy on the sun's spectrum depends upon the distance the light has to pass through the atmosphere.
6. At noon, in the higher altitudes, light is relatively rich in violet, while at twilight or at sea-level it is relatively rich in red.
7. Direct light is disproportionately stronger at the higher altitudes than at the lower places.
8. At Davos, Switzerland, if the annual average total light is set equal to 100, then the direct is 85.5 and the diffused is 11.5.
9. At mean sun height the direct light is never equal to the diffused.
10. At mean sun height, at Davos, the total light is 9 when diffuse is 1, as an annual average.
11. At same place, when the sun passes from 10° to 65° above the horizon, the direct light increases eight times, while the diffuse increases only two times. Davos is about 5,000 feet elevation.
12. With increase in altitude direct light increases at a greater rate than diffuse light decreases.
13. Increase in intensity of light in going from lower to higher altitudes is due to the direct light.
14. Importance of diffused light is comparatively small in highlands if we ignore reflections from snow, ice, rocky walls, etc.
15. Importance of diffused light in lower altitudes is greater than that of direct light.
16. Total brightness may be greater when sky is partially cloudy than when cloudless; but when the sun goes behind a cloud the total is decreased from 30 per cent to 50 per cent on an average.
17. Diffused light makes up a larger share of total illumination in lowlands than in highlands.
18. At Zürich for nearly 60 per cent of the time between sunrise and sunset illumination is from diffused light only.
19. The amount of time that many plants receive actual sunshine is diminished by the neighboring plants.
20. The fixed light position of leaves is determined by the strongest incident diffused light.
21. Exclusion from direct radiation during the first decade does not alter the growth of different species nor the height growth for the same species.

22. On a cloudy day the total light may be as low as 1/100 of that on a clear day, and a cloudy day in winter may be only 1/200 or 1/300 as light as a clear day in summer.
23. The color composition as well as total intensity is changed by clouds; the longer wave-lengths are absorbed, especially ultra-red; in the blue, absorption is not especially strong, but increases in the violet and ultra-violet to complete extinction.
24. There is a great variation in the composition of diffused light from an apparently unchanging clear sky, due to changing amounts of the minute particles suspended in the atmosphere.
25. Even the radiation of the sun is not constant; a 10 per cent change in intensity may occur in a few months sufficient to change the temperature on the earth several degrees.
26. On clear days, when the sun is low, the zenith is the darkest part of the sky. The brightest point lies near the position of the sun. When the sun is higher, up to 30°, the darkest point moves proportionally to the north, but not in the same degree as the sun. When the sky is uniformly cloudy, the brightness increases from horizon to zenith.
27. In dealing with small sections of the sky, vapor movements produce differences in intensity that would not be noticed in the total brightness of the whole.

The author gives the data from the readings of a clear midsummer and a clear midwinter day. These show that the zenith brightness increases with the rise of the sun and reaches at midday 5 to 10 times the amount of illumination at sunrise. They also show that, with high temperature and great humidity, the difference in illumination between two readings varied by 50 per cent; while on the cold day, with low humidity, there were only slight unimportant changes. They also show that the color composition changed in the course of the day. Single light measurements under trees would therefore be worthless unless compared with the light in the open, and then expressed in relative terms. These measurements should be made within half an hour of each other and on uniformly clear or cloudy days; those in the forest should be preceded and followed by measurements in the open.

Two instruments working at the same time would overcome the weather difficulty which necessitated 188 set-ups of one instrument in order to get 127 usable readings, 32 per cent useless measurements.

For light transmission through green leaves the author cites these points from the literature:

1. Only a small part of the light falling upon a green leaf passes through, and that is qualitatively changed.
2. The rays between the B and C lines of the spectrum and at F and in the violet are absorbed. If several thicknesses of leaves are used, only a little yellow-green light is transmitted. Ultra-red rays are absorbed least.

3. Absorption of short wave-lengths is ascribed to all other parts of the cell in addition to the chlorophyll.
4. In light that has passed through a leaf, assimilation becomes too weak to use all the carbon dioxide formed by metabolic processes.
5. Chlorophyll absorbs most of the light.

Several plates of sun-prints made on celloidin paper show that the light passes through the veins in far greater amounts than through the green web. Shade leaves allow much more light to be transmitted than light leaves; this, however, is to be expected from the structural differences. Young leaves allow more light to pass through than the older ones of late summer.

Several series of measurements are given which were taken to determine the intensity of the various spectral areas of diffused daylight and direct light that had passed through leaves of several broad-leaf species.

The diffused daylight penetrated in per cents as follows:

	Shade leaves. Per cent.	Light leaves. Per cent.
Red	9–12	0–8
Yellow	11–19	6–15
Green	16–25	6–12
Light blue	5	2–5
Dark blue	trace	0–2

The maximum in the yellow-green, from 589 to 520 $\mu\mu$ in diffused light, was moved up toward the red in the direct light of the sun.

From these measurements it seems conclusive that light, in the forest, which passes through the leaves, whether the sun shines on them or not, is richer in yellow-green light than in the other colors. The filtering effect of the leaves is similar in different species of broad-leaf trees. More light passes through shade leaves than through light leaves.

Conifer needles were not investigated, but the author thinks that the quantity of light which passes through the needles is so small that it has no influence upon the light of the stand.

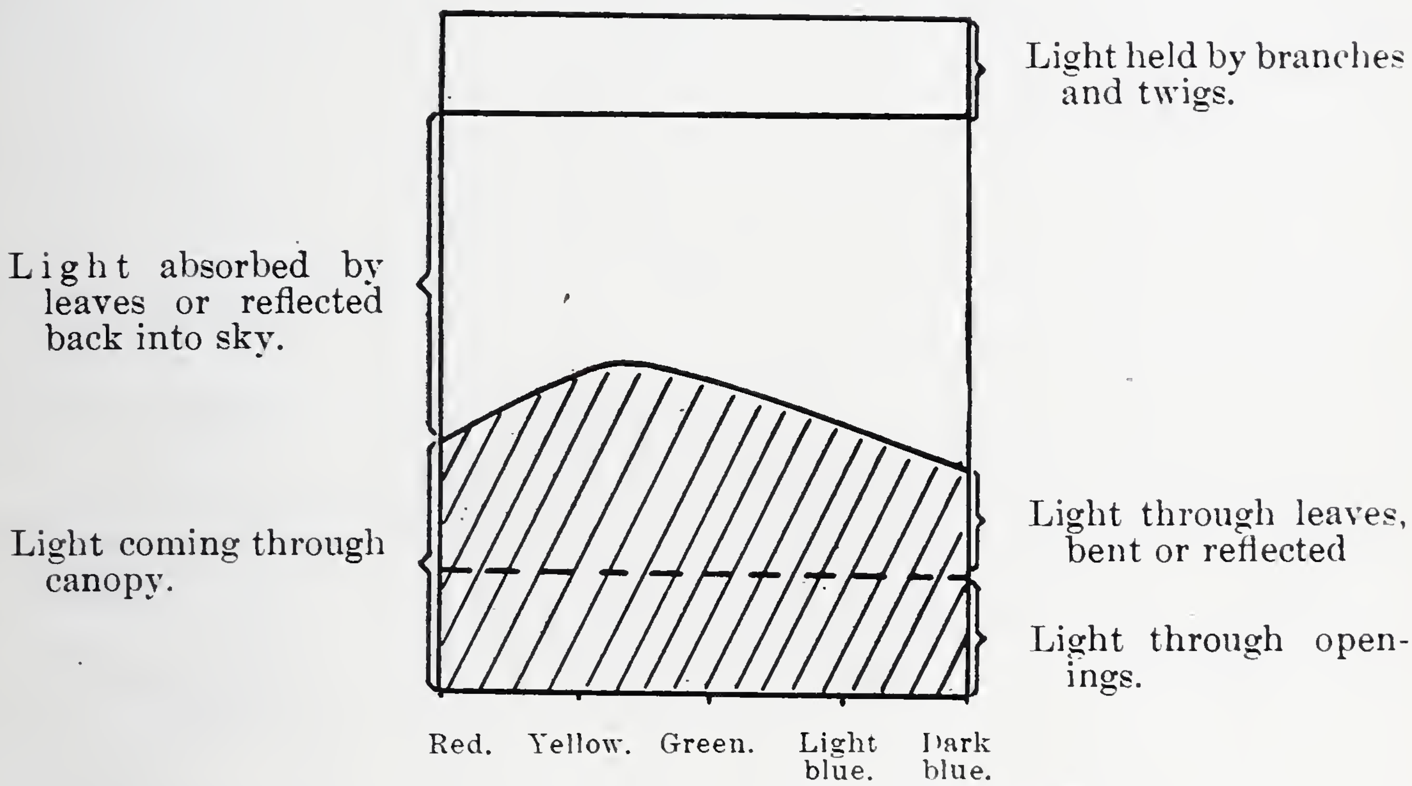
Under single trees or in the interior of a stand, light is composed of the following various kinds, if side-light is not considered:

1. Of unchanged light that passes through the crown-cover.
a. For a single tree; light that passes through the interspaces of the crown.
b. For the stand; light that passes between the crowns of different trees.
2. Of light that passes through the leaves.
3. Of light which is reflected on the surfaces of leaves and branches and is refracted at the margins of the leaves.

Concerning 1, the quantity of light that passes through the crown or canopy depends upon the species, age, degree of foliation, season, health, tree in open or in stand, pure or mixed stand, density of stand, and intensity of light that falls on the crown. Regarding 2 and 3, the color composition is different from that above crowns, since part is changed in penetrating leaves and part by diffusion.

The light, then, that reaches the floor of the forest is composed of the components represented in the following diagram:

100 % = Diffused light falling upon crowns.



Of these components it is possible to measure, besides the light that passes through the leaves, that which is held back by the branches and twigs and also the total intensity of all that reaches the forest floor.

Measurements were made and the data cited for about 110 observations, made under single trees and in stands of various conditions of these species: beech, ash, walnut, basswood, sycamore, locust, pear, fir, pine, spruce.

The following table is a summary showing the per cent of the light that passed vertically through the crowns of open-grown trees:

	Red, per cent.	Yellow, per cent.	Green, per cent.	Light blue, per cent.	Dark blue, per cent.
Beech, basswood, horse-chestnut..	trace	2–4	2–4	trace	trace
Sycamore.........	1	Up to 5	Up to 7	1	1
Walnut, pear.....	10–12	15–17	10–12	5–15	3–9
Locust...........	16–17	24	16–17	10	10

In all cases the yellow and green are in excess, and the composition is similar to that of light transmitted by the leaves, excepting that the individual leaf seems to allow little or no dark blue to pass through. The amount of dark blue in these measurements might be used as an indicator of the total amount of unchanged light that comes through the interspaces of the crown.

The light that penetrated crowns of conifers showed no difference in color composition from that of the light in the open, with exception of a slight change in case of the pine.

For stands grown on good fresh soils of Sites I and II the following table gives the results obtained as averages in per cent of total light in the open:

	Red.	Yellow.	Green.	Light blue.	Dark blue.
Beech: Close stands, old and middle age............	4.5	6.4	4.9	2.5–3.5	2.5–3.5
Beech: Strongly thinned stands, old and young........	22–25	25–35	18–20	12	12
Ash: Closed stand............	21	30	20	10	8
Birch: Closed stand............	22	28	28	21	23

When the beech is illuminated by direct sunshine, it allows only twice as much light to penetrate as when illuminated by diffuse light for young and middle-age stands, while in old stands just a trifle more penetrates. Reflection back into the atmosphere is the explanation.

In the conifer stands, as under the single tree, there is no change in the quality of the light that reaches the forest floor. Since the needles are so thick that measurable quantities do not penetrate, the light in the interior of a stand is that which comes through the spaces between the crowns instead of that which filters through the leaves, as in hardwoods, or instead of that which passes through the interspaces of the single crown, for it was shown that no measurable quantity comes through the individual crown. The light that reaches the floor, then, of spruce, fir, and pine stands is unchanged in color composition, while intensity is a matter of the spaces between crowns and a matter of height of trees.

The broad-leaf trees exercise selective absorption which expresses itself in the light of the stand by the prevalence of yellow and green over the remaining spectral areas. Even with a very close canopy, some yellow

and green light penetrates vertically. In broad-leaf stands single colors must be considered, while in coniferous stands the total light must be measured.

The conifer crowns may be compared to a lattice-work screen which lets the light through completely in some places and in others not at all, while the broad-leaf crowns act like a colored glass which allows only light of a definite wave-length to penetrate.

The extremely strong extinction of daylight in passing through the crowns led the author to investigate the question of the absolute area of the leaves of a tree in relation to the area occupied by the tree in the stand. Professor Engler investigated the area and number of leaves of 11 trees—beech, fir, and spruce—varying from 50 to 150 years of age. His data are given in the table below:

Number and surface area of leaves.

D.b.h., c.m.	Age, years.	Number of leaves, in millions.	Surface of both sides, in square miles.	Tree class.	Volume.	
					Twigs, cu. m.	Whole, cu. m.
			BEECH.			
37	96	0.119	285	Dominant	0.218	1.758 [1]
			FIR.			
72	155	39.680	1825	Dominant	1.546	7.629
41	157	20.170	930	Codominant	0.536	2.464
18	156	3.370	155	Intermediate	0.102	0.354
			SPRUCE.			
61	117	20.043	702	Dominant	0.763	5.275 [2]
42	135	9.036	316	Dominant	0.314	2.121 [2]
25	116	4.195	147	Codominant	0.098	0.626 [2]
11	48	1.499	52	Suppressed	0.022	0.077
34	55	11.720	351	Dominant	0.265	1.495
24	55	5.327	160	Codominant	0.090	0.597
14	55	0.896	27	....	0.027	0.169

[1] Arithmetical average of stand. [2] Diseased.

Through a graphic representation of leaf surfaces the probable surfaces for trees of equal diameters of the three species were determined, and when compared to the number of trees per hectare it was found, when con-

sidering the surface of only one side of the leaves, even of a thin beech stand, that it surpasses the stand area several times, and that in a closed spruce stand the total needle surface amounts to more than ten times the stand area.

The total surface of the beech leaves on a hectare was 5.6 hectares; of the spruce, 12.8 hectares.

When investigating the amount of light under the leafless crowns of beech, the author found that the reflection from the trunk and twigs when the sun is shining increases the light in the stand by 10 per cent to 20 per cent over diffuse light in the open. This is probably of importance to the spring flora and also to the unfolding of the leaves, which progresses from below upward.

Measurements taken when the sun was not shining show that the branches and twigs reduce the light intensity by almost one-half; in an ash stand by about 30 per cent; in an old beech stand it may reach as much as 60 per cent.

The accurate process used here has discovered peculiarities of the light conditions under the crowns of trees which could not have been recognized by simpler means. The instrument used is limited in its use by its size and delicacy and also by its requirement of two men to manipulate it. However, it may become a standard to which simpler methods can be checked and compared.

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REPORTS SUBMITTED AT THE ANNUAL EXECUTIVE MEETING OF THE SOCIETY, HELD IN NEW YORK, JANUARY 11

The Society of American Foresters

BY B. E. FERNOW

This meeting—the annual meeting of the Society—has been called as a business meeting; hence there is nothing to be discussed here except the business of the Society.

The activities for the current year and the business condition of the Society will be presented in reports of the Secretary, Treasurer, and Executive and other committees. For the President it may be left to reflect on the progress for the *future,* to suggest how the aims and objects of the Society may be attained in increased measure by further development.

The proposition to bring about certain changes in the organization of the Society by amendments to its Constitution has produced correspondence between the Executive Committee and prominent members, which is of great interest in showing that even the fundamental conceptions as to the object and aims of the Society are by no means uniform and settled.

What are the objects of our Society? One of the older members replies: "To give a standing to its members, to *be* rather than to *do!*"

This, to be sure, should be *one* of the aims, and a prominent one. Membership should represent character; but if that were all, if the Society were merely, say, a club of the upper four hundred, the Society would, in my opinion, not only not be worth while, but indeed at present be still impossible for lack of a sufficient number of men deserving to be in it.

The same correspondent writes pertinently: "Individual accomplishment is everything," and "we shall gain credit only through what our members do." But he adds: "Society activity is not likely to be of great importance," and "we shall not gain credit through what the Society does."

If this last prognosis were correct, it would indeed be a sad contemplation for the usefulness of the Society; its *raison d'être* would be nil, or nearly so. But has the writer informed himself what other societies have done as such for their members and their profession? Is he justified in the pessimism regarding our own?

In general terms, the object of the Society is perhaps well enough expressed in Article II of its Constitution, namely, "to further the cause of forestry by fostering a spirit of comradeship among foresters; by creating opportunities for free interchange of views upon forestry and allied subjects, and by disseminating a knowledge of the purpose and achievement of forestry."

There are, then, *personal advantages, professional advancement,* and *public education* involved in these three aims of the Society. How these aims can best be attained, what specific methods may be employed, are questions capable of wide discussion and considerable difference of opinion.

The first question that arises is how the membership is to be composed that is "to foster a spirit of comradeship among foresters."

While this reading seems to imply a thoroughly democratic spirit and appears all-inclusive, Article III of the Constitution places a limitation of doubtful meaning on the composition of the membership, namely, admitting only "professional members of *achievement*" and "associates of *achievement*," besides honorary membership.

What is "professional," and especially what constitutes "achievement?"

It may not be difficult to define as a professional the man who has secured technical training at a higher grade forest school, intending to make forestry his life-work. Especially, since we have standardized forestry education, the amount of education necessary for the professional man is at least approximately defined.

But what is "achievement" is much more difficult to define. A wide limit of personal judgment as to standards will here prevail; and, moreover, with time, the standard must necessarily change, and that considerably, as opportunities for achievement vary, unless achieving the degree from one of the schools or attaining a position in one of the forest services or schools are deemed sufficient to satisfy the requirement.

While I would not go so far as another correspondent, who would open the door unconditionally to any one interested in forest work, I consider that the Society could best serve the object of fostering a spirit of comradeship in the profession and of furthering the cause of forestry in general by admitting even those young aspirants who have not yet had a chance to fulfill the conditions of "achievement," but have an ambition to do so.

The Society should, in my opinion, represent the *whole* profession as a working unit before the public. Its membership should practically include all those who can claim to have a professional training and are otherwise—that is, morally, proper persons; and *membership should be*

not only such an honor, but such an advantage that every fit man would seek it.

This wholesale assembling of the entire profession needs by no means to be done without distinction of relative merits, but this distinction should be made rather *within* than *outside* the Society. In other words, a classification of membership beyond that at present in existence is needed. At present we have only one class of professional members, those of "achievement." Would it not be wise to add a junior membership to these seniors?

This would not only increase membership and with it bring shekels, but it would increase the interest in the Society and broaden its influence.

There would then still be room for ambition to advance from junior to senior membership by really *notable* achievement. Such senior members may then be designated as Fellows or by some other distinctive appellation. Other successfully conducted professional societies are based on such classified memberships, such as the American Institute of Mining Engineers, the Societies of Civil and Mechanical Engineers, etc.

While I am, then, inclined to liberalize membership requirements under conditions of classification so as to admit nearly all professional foresters, I see from the latest list of proposed members that the Membership Committee has apparently gone far beyond a reasonable liberality in the interpretation of both terms, "professional" and "achievement," by proposing many new members who do not respond to our definitions of either one or the other of these terms.

It would, in my opinion, be a great mistake, without *further classification*, to admit to active membership any but strictly professional foresters; while, *with classification*, we may take in everybody who is engaged in professional work which even distantly is related to forestry. The management and representative body of the Society should always be reserved to *bona fide* professional foresters.

Incidentally, I may refer to the method of voting for members by the entire membership as cumbersome and by no means producive of good results, since the majority of members, I fear, may exercise their voting privilege only mechanically, and often cannot have much judgment as to the fitness of proposed members.

To increase the value of membership in the Society, especially of senior membership, there must be a contrivance which makes such membership a *prima facie* testimony to professional standing before the public, so that eventually the outside applicant for employment will have to explain why he is not a member.

This contrivance lies, of course, in the first place, with the membership

itself living up, and making its members live up, to high standards; but there is also a mechanical device which may be used to protect these standards, namely, by *incorporation* of the Society.

Such incorporation gives not only the right to hold property, but it can patent the use of the Society's name, so that F. S. A. F. (Fellow, Society of American Foresters) or M. S. A. F. (Member, Society of American Foresters) or any other designation that may be decided upon becomes a valuable introduction reserved to members.

The Society of Canadian Foresters has lately decided to so incorporate and expects thereby to be of greater value to its members.

In this way the Society would indeed "give a standing to its members."

Let me read you the wording which the Canadian Society has adopted in its charter to cover this point:

"In order that the public interests may be better protected, and in order that persons requiring professional aid in any work to which knowledge of forestry and forest engineering is applicable or necessary may be enabled to distinguish between qualified and unqualified Foresters or Forest Engineers, the charter is *to restrict* the use of the name and title of Forester or Forest Engineer, or any abbreviation thereof, either alone or in combination with any other word or words, or any name, title, or description implying membership in the said Society of Canadian Forest Engineers, to such persons as may be members of this Society or as may be duly qualified Foresters or Forest Engineers and entitled to use the title of Forester or Forest Engineer by the authority of some institution of learning having legislative authority to confer degrees in Forestry or Forest Engineering; or unless he is a member in good standing of some Society of Foresters or Forest Engineers in Great Britain and Ireland or in any other portion of the British Empire outside of Canada, or in any foreign country."

The second object of the Society, namely, advancing professional forestry by interchange of views, can be attained only by meetings and by print, and here we may, in part, agree to what our first-quoted correspondent asserts: "We shall gain credit only by what our individual members do." Yet there are some things which can be done only or mainly by associated effort, by committee work.

Just at present a committee of 21 is wrestling with the compilation of a standard terminology and synonymy—a herculean task, if properly done, which no single worker or small group of workers could accomplish; for it requires the consensus of a majority to establish any standards. A progress report of the five subcommittees, which have

divided the field into groups of subjects, has appeared in the last issue of the Quarterly.

There are other subjects for standardization, in the handling of which, contrary to our friend's opinion, society activity may be of great importance. The appointment of other committees to work out standardized methods of procedure in various lines of investigation has waited for the result of a canvass of the membership to discover the most promising members to work in such committees.

While coöperative experimentation is probably sufficiently attended to by the Forest Service, it is conceivable that some problems might be suggested which could be better solved by committee work of the Society.

The exchange of views at meetings and in print will, however, be necessarily the most general methods of advancing forestry interests.

Print costs money; yet if the membership were increased as proposed, there would perhaps be sufficient to print and distribute all that is worth while, besides the literature put out by official documents. The *Proceedings* have been a worthy product of the Society, taking care of the weightier matters, and for more ephemeral discussions the *Forestry Quarterly* has always been open.

There is a proposition on foot to amalgamate these two publications into the American Journal of Forestry, to be published in eight monthly issues, combining the features of the two original magazines.

Such a publication, to be made the official organ of the Society, would become a medium for more lively exchange of views than the two quarterly publications and should greatly stimulate interest among the membership. The details of this proposition, especially as regards the financial aspects, will be submitted to you as a part of the business of this meeting.

Referring to *finances,* myself, with a number of members, believe that a mistake was made when the dues were reduced from $5 to $3.

This was done at a time when the Society was not as yet strong enough to deliver a *quid pro quo,* when some members did not see that, with the growth of the profession and the membership, the advantages accruing from membership could be made in proportion to the funds at disposal. At present there would appear no difficulty in using a larger income profitably for the benefit of the members, were it only by supporting a worthy organ of communication.

The experience of most societies is that when they have outgrown what we may call the infantile stage, a paid, or at least partially paid, secretary is a necessity for keeping the society in active operation. This is no reflection on the efficiency of our secretaries, who have hitherto volun-

teered their services to a rather thankless task, but a recognition of the fact that the routine work alone of the secretary has grown beyond the limit when we should expect it to be done as a labor of love; and there is other than routine work which a secretary can do to keep the society active, and which the volunteer secretary, as a rule, is unable to attend to. Permanency in the office of secretary, everybody who has served in such capacity will admit, is most desirable, and hence I would suggest a return to the $5 fee and the installation of a paid secretary.

Finally we come to *meetings* as a means to attain the objects of the Society.

While the Society is small in numbers, and at that scattered over the whole country, it stands to reason that hardly ever a fully attended representative meeting is possible. By necessity, meetings of the Society can only be sectional, local, and small; yet the meetings are, or can be made, of greatest value in promoting comradeship, in bringing out hidden knowledge, and in educating the public. Hence, to make the use of this means of fostering forestry more effective, it is suggested to extend the formation of branches or sections, a few having been in existence for some time. Even then, if the membership of sections is confined to members of the Society itself, they would probably be too small to make frequent meetings successful. It is therefore proposed to permit sections to increase their membership from outside the Society by electing associate members or assessors from men who are more or less technically interested in forestry, like lumbermen, wood manufacturers, etc., and from assistants who are not or are not yet eligible to the Society. In this way the object of the Society of "disseminating knowledge of the purpose and achievement of forestry" may also, to some extent, be accomplished.

Such enlargement of the membership of sections would have the advantage of creating centers of education of sufficient size to make frequent meetings possible and interesting. A monthly dinner, for instance, with a program for discussion before and after, would accomplish all objects.

It would, of course, be necessary to carefully formulate the conditions under which this accessory membership of sections may come in without bringing trouble to the Society itself.

This proposition, I find, is by no means new. At an executive meeting of the Society in 1910, and again on February 2, 1911, an amendment to the Constitution was approved to permit just such organization of sections, under proper safeguards; but it does not seem to have become a part of the Constitution, and its adoption should be urged anew.

In the end, we must not overlook the fact that our profession is still very young in this country; that it is still represented by small numbers, and hence we cannot expect to secure the fullest measure of advantage of association which older, more developed professions, with their larger number of devotees and more specialized fields, can secure.

There are those who sit back, finding fault because the Society apparently does not do them any good. Such critics need to be reminded that the member whom I quoted at the start is right in the one expression, "Individual accomplishment is everything"; even the success of a society is built on individual endeavor.

There are, then, six directions in which we can improve our Society to fulfill its mission:

1. Broadening its membership through classification of members.
2. Incorporation of the Society to assure its members special standing in the community.
3. Amalgamation of the *Proceedings* with the *Forest Quarterly*.
4. Return to the original membership fee of $5.
5. A paid permanent secretary.
6. Organization of sections, with increased membership beyond that of the Society itself.

Report of Executive Committee for the Year 1914

The Executive Committee submits the following report covering its activities during the year and its recommendations concerning the interests of the Society:

1. SOCIETY EXPENDITURES

A subscription of $10 to assist the International Union of Forest Experiment Stations in compiling a bibliography of forestry literature was authorized. The committee also approved the payment of the expenses of the Secretary of the Society incurred in attending the executive meeting held at Ithaca, N. Y., on May 16, 1914.

In view of the policy now in effect, of holding one or more meetings annually away from Washington, the adoption of a standing rule authorizing the payment of the Secretary's expenses in attending all such meetings has been suggested. The Executive Committee is compelled to recommend against this course as a uniform practice. While recognizing its value in promoting coherence in the activities of the Society, we believe that the present financial resources of the organization do not justify it. The plans for 1915 include a meeting at San Francisco in

connection with the Panama-Pacific Exposition. Other meetings will doubtless be held from year to year at points at considerable distances from Washington. To pay the Secretary's expenses in attending all of these meetings would cause, in our judgment, an unwarranted drain upon the funds of the Society. We believe that other uses of this money, particularly in promoting the technical work of the Society, are more important.

While the uniform attendance of the Secretary would be very desirable, therefore, we feel that it should wait until the Society's finances justify this additional burden. In the meantime the Executive Committee should authorize the payment of such expenses in special cases, in advance, when the distance is not great and the attendance of the Secretary is particularly desirable.

2. EXTENSION OF THE MEMBERSHIP AND LOCAL ACTIVITIES OF THE SOCIETY

During the year the Executive Committee approved the establishment of the Portland, Oregon, Section of the Society, representing the Pacific Northwest, upon petition from 19 Active members. The territory embraced in this Section includes, aside from the States of Oregon and Washington and the District of Alaska, the Province of British Columbia.

In accordance with the policy advocated in the report of the preceding committee and endorsed by the executive meeting of the Society held at Ithaca, N. Y., on May 16, the Executive Committee has initiated a campaign to extend the local activities and influence of the Society through the establishment of additional Sections and the affiliation of local forest organizations. A circular letter has been prepared which will be sent to every member of the Society in a region not now covered by a Section, setting forth the aims and desires of the Society in this respect and urging united action by the members in the region to bring about the establishment of a local Section. For this purpose the members of the Society have been tentatively grouped in the following regions:

The New England States;
Pennsylvania, New Jersey, and Maryland;
Arizona and New Mexico;
Utah, Nevada, and southern Idaho;
New York State;
California;
Colorado, Wyoming, Nebraska, and South Dakota;
Eastern Canada.

It has been further planned to supplement this action by correspondence with certain members in each region who may be willing to take the leadership in organizing a Section, and by assigning particular regions to each member of the Executive Committee for personal work in following up and aiding the establishment or affiliation of a local organization. It is earnestly advocated that these efforts be continued as one of the most effective means of identifying the Society of American Foresters with the varied forestry interests throughout North America and extending its influence and usefulness.

In line with the foregoing and also in pursuance of the policy advocated at the Ithaca meeting, the Executive Committee has had under consideration, in collaboration with the President of the Society, a number of amendments to the Constitution designed to facilitate the upbuilding of local Sections and broaden the membership of the Society. After obtaining the views of a number of members, the committee proposes tentatively the following amendments, not as expressing the united judgment of the committee, but as the preferable form for presenting these matters for ballot by the entire membership of the Society.

Junior Membership

ARTICLE III

Amend Section 1 to read:

> "Members may be Active, Associate, Honorary, or *Junior*."

Amend Section 5 to read:

> *"Junior members shall be persons who have completed professional training in forestry equivalent to graduation from a forest school of recognized standing. They may attend all meetings of the Society and take part in its discussions, but shall not be entitled to vote."*

Section 6 will be the present Section 5, amended to read:

> "Any Active member may propose names of candidates for Active, Associate, Honorary, or *Junior* membership," etc.

Section 7 will be the present Section 6.

ARTICLE X

Amend Section 1 to read:

> * * * "and of Associate and *Junior* members, two dollars."

The purpose of these amendments is to provide for a class of Junior members, consisting of men fresh from the forest schools, who may thus be identified with the Society and participate in its work at the outset

of their professional career. A similar provision is contained in the Constitution of the American Society of Civil Engineers. This course seems advisable to a majority of the members of the Executive Committee as a means of extending the membership, increasing the financial support, and broadening the influence of the Society. On the other side, it is opposed as confusing the standards and membership requirements of the Society in the popular mind and as an undesirable step in the direction of lowering its ideals.

Local Sections

ARTICLE VIII

Amend Section 1 to read:

> * * * "written petition of *five* or more Active members. Only Active members of the Society shall be eligible to *Active* membership in a Section. *Each Section, however, may elect Associate members subject to such qualifications and requirements as shall be fixed by its own By-laws. Such election shall not convey Associate membership in the Society."*

Amend Section 3 to read:

> *"The By-laws adopted by any Section for its own government, including the qualifications for Associate members, shall be subject to the approval of the Executive Committee."*

These amendments are designed to encourage the formation of local Sections by (1) reducing the minimum number of Active members required from ten to five and (2) giving the Sections wider latitude in the election of Associate members. The latter is designed to permit Sections to adapt their Associate membership to local conditions, so as to be able to affiliate with the Section the type of local man best calculated to make its work effective. It is felt that the requirement that the By-laws of the Section be approved by the Executive Committee of the Central Society will be an adequate safeguard against lowering the qualifications for Associate membership unduly, while permitting necessary flexibility in the choice of Associate members by Sections.

The Executive Committee is desirous of obtaining a full discussion of these tentative proposals at the January meeting, before they are framed in final form for letter ballot.

In this connection the policy of the Society in respect to the qualifications demanded for Active membership may properly be considered. The following statement on this subject is furnished by Mr. Du Bois:

"The Constitution provides three specifications for an applicant for Active membership:

"1. He shall be a professional forester.

"2. He shall have achieved something definite in his profession.

"3. His field of work shall be in United States territory or Canada.

"*What is a professional forester?* It is one who is actively working or qualified by training or experience, or both, to actively work in one or more of the major divisions of forestry—silviculture, forest protection, forest administration, or forest utilization. Simply because a man may be in the employ of the Forest Service or of a lumber company does not settle the question of his profession. In the former he may be a hydro-electric engineer, in the latter an accountant. If, however, he is a forest supervisor in charge of a timbered forest, it does settle the question of his professional status. He must be a forester, though he may be a very poor one, who does not meet the other requirements for Active membership in the Society.

"*What constitutes professional achievement?* Results of his work which have made for a real advance in the sum total of scientific knowledge of American forests and their conservative management—*or in the welfare of the forests in which his activities lie.*

"A professor in a forest school, himself a graduate of one, is, without doubt, a professional forester; but if he teaches only the facts which were taught him, if he discovers no new facts or reaches no new conclusions or produces no new and valuable ideas, but merely turns out mediocre young foresters, is not a professional forester of achievement.

"On the other hand, a forest ranger who, by original thinking, experiment, or study, develops and puts into successful operation a new method in fire protection, cheaper and more effective than the old one, and as a result his district becomes stocked with young forest, he is a professional forester of achievement.

"Achievement, in this sense, may be shown in the man's writings or in the woods under his care. The former has always been recognized, the latter not always.

"His field of work is simply a matter of facts easily ascertained.

"This viewpoint of what should be the qualifications for Active membership broadens and rationalizes the matter; it does not let down the bars—it merely sets them straight."

It may be of interest to note in this connection the provisions of the Constitution of the American Society of Civil Engineers dealing with Active membership, as follows:

"2. A Member shall be a Civil, Military, Naval, Mining, Mechanical, Electrical, or other professional Engineer, an Architect or a Marine Architect. He shall be at the time of admission to membership not less

than thirty years of age, and shall have been in the active practice of his profession for ten years; he shall have had responsible charge of work for at least five years, and shall be qualified to design as well as to direct engineering works. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice. The performance of the duties of a Professor of Engineering in a technical school of a high grade shall be taken as an equivalent to an equal number of years of actual practice."

The Executive Committee does not advocate lowering of the standards of the Society for Active membership. We believe, however, that they can be made more rational and more clearly adapted to American conditions by admitting men of practical training and experience as well as those of technical schooling in forestry, and by placing the major emphasis upon achievement rather than upon a specialized type of preparation. We believe that the example of the American Society of Civil Engineers in this regard might well be followed. The requirements as to achievements in professional forestry should be high and specific; but men who have met this test in the practical work of forest administration or forest protection or forest utilization should be admitted to membership no less than the man of technical training whose achievements have also been distinctive.

3. MORE STABLE ORGANIZATION OF THE EXECUTIVE COMMITTEE

The Executive Committee is under a serious handicap because of its widely scattered and constantly changing membership. This committee should perform a very useful service for the Society by investigating and reporting upon matters affecting its policy or the constructive development of its work. The members of the committee are always busy men and its work is necessarily delayed by their scattered location, with the consequent necessity for the transaction of business by correspondence. Many of the subjects taken up by the Executive Committee within the past three years require study and consideration for a long period, in order to handle the questions involved efficiently for the best interests of the Society.

The effective discharge of these functions is necessarily handicapped by the annual changes in the personnel of the committee, often amounting to practically an entirely new personnel. We believe that the interests of the Society would be furthered by a more stable organization, providing for gradual rather than sudden and complete changes in the personnel of the committee, and permitting greater coherence and continuity in its work. For these reasons we recommend the adoption of

an amendment to the Constitution of the Society making the term of members of the Executive Committee five years and providing for the election of one member each year. In the first election it would be necessary to elect the members of the committee for designated terms, ranging from one to five years respectively, or to fix the terms by lot. Thereafter the annual election of one member would carry out the plan proposed.

Respectfully submitted,

W. B. Greeley,
For the Executive Committee.

Report of the Secretary for the Year 1914

MEETINGS

Nine open and six executive meetings of the Society of American Foresters were held during 1914. The following list gives a program of the meetings—first open, then executive.

Open Meetings

January	8.	Methods of studying yields per acre on the basis of age for all-aged stands.	Herman H. Chapman.
February	5.	The management of lodgepole pine.	D. T. Mason.
March	5.	The proper basis for land classification.	Franklin W. Reed.
April	2.	New developments in the eastern wood-lot problem.	Bristow Adams. J. H. Foster. F. F. Moon.
May	7.	The National Forests of Alaska.	Earle H. Clapp.
October	22.	Forest planting in Arizona and New Mexico.	G. A. Pearson.
November	19.	Reclamation and Forestry.	C. J. Blanchard.
December	17.	Administration of the National Forests in the Southern Appalachians.	Karl W. Woodward.

Executive Meetings

January	22.	Annual executive meeting.
May	16.	Executive meeting to consider report of Executive Committee.
June	17.	To adopt resolutions on the death of Overton W. Price, active member.
July	29.	To adopt resolutions on the death of Louis Margolin, active member.
November	7.	To adopt resolutions on the death of Henry Gannett, associate member.
November	20.	To consider question of meeting places.

The fifteen meetings of the year represent the largest number held so far in a twelve-month.

The average attendance at open meetings was 50, also the largest average attained, due in part to the open meeting in Cornell in May, attended by 256. The lowest attendance was 8; the average, leaving out these two extremes, was 27. At the Executive Committee meetings the average attendance was 16, with the largest at Cornell in May, with 31 members present.

MEMBERSHIP

During the year the Society lost by death three members—two active and one associate—Overton W. Price and Louis Margolin and Henry Gannett.

A general reorganization of membership in accordance with the revised Constitution is in progress, but has not been completed at this date.

During the year 18 active and 8 associate members were added.

The present membership is 299, divided as follows: Active, 240; associate, 58; honorary, 1. Total, 299.

ACTIVITIES OF THE YEAR

1. No amendments to the Constitution were made during the past year.

2. In accordance with a decision of the Executive Committee, five issues contained in the report of the 1913 Executive Committee were drafted into ballot form and submitted to the Society. To this ballot 70 members responded, with the following results:

	Vote. Yes.	Vote. No.
1. Shall one meeting yearly be held outside of Washington?	62	2
2. Shall a strong effort be made to organize local sections and affiliate local organizations with the Society?	57	10
3. Shall committees be appointed to take up the question of nomenclature and terminology, the standardization of scientific matters, and the bringing together of information regarding investigative projects?	68	2
4. Shall the Society investigate scientific problems of public importance and officially endorse the conclusions of such investigations if two-thirds of the members concur?	37	27
5. Shall the President and standing committees select one or more subjects for investigation under the provisions of No. 4 above?	43	21

The first and third decisions are now in operation. The Committees on Nomenclature and Terminology have already performed a large amount of work.

No action is in progress on the other three decisions.

A mimeographed circular by Dr. B. E. Fernow, entitled "Policy of the Society of American Foresters," was distributed to members. This is a reprint of the President's address at Ithaca.

The stenographic and clerical work of the Secretary has been largely performed by Mrs. Conway without compensation, as has been customary. In view of the increasing amount of work which is devolving upon the Secretary, it is proposed to employ one of the Forest Service stenographers during the present year to handle correspondence and take charge of the Secretary's files.

ROBERT V. R. REYNOLDS,
Acting Secretary.

REPORT OF ANNUAL ELECTION

In the annual election closed January 8, 1915, the successful candidates were as follows:

For President, W. B. Greeley.
For Vice-President, Raphael Zon.
For Secretary, Karl W. Woodward.
For Treasurer, Louis S. Murphy.
For members of the Executive Committee, R. S. Hosmer, Filibert Roth, H. O. Stabler, F. A. Silcox, R. Y. Stuart.

In this election, as in several other recent elections, the members showed too little interest in the conduct of affairs of the Society. Only 167 valid ballots were cast out of the active membership of 240. Eight ballots were thrown out because they were unsigned. If counted, however, these votes would not have changed the results.

ROBERT V. R. REYNOLDS,
Acting Secretary.

REPORT OF THE TREASURER FOR THE YEAR 1914[1]

JANUARY 1, 1915.

RECEIPTS

Balance from previous year		$602.65
Annual dues:		
Active members, 1912	$12.00	
1913	33.00	
1914	681.00	
1915	7.00	
	733.00	
Associate members,[2] 1914	15.00	
		$748.00

[1] Audited by C. R. Tillotson and W. B. Barrows and found correct.
[2] Members elected under constitutional provision effective beginning the year 1914. See also note under "assets."

Sale of Proceedings:			
Subscriptions, Vol. VIII (1913)	$123.00		
Subscriptions, Vol. IX (1914)	500.01		
Subscriptions, Vol. X (1915)	4.00		
Miscellaneous numbers	154.25		
		781.26	
Proceedings, Vol. IX, special plate matter paid for by authors		50.06	
Interest:			
January 1 to June 30, 1914	$7.56		
July 1 to December 31, 1914	5.13		
		12.69	
Miscellaneous		.37	
			1,592.38
Total			$2,195.03

DISBURSEMENTS

Proceedings, Vol. IX (Nos. 1, 2, and 3, 600 copies each, and No. 4, 700 copies):			
Printing, etc.	$1,295.28		
Proof-reading	58.00		
Postage (to members and subscribers)	10.00		
Envelopes	11.75		
Miscellaneous	7.50		
		$1,382.53	
Postage (including postage on miscellaneous copies of Proceedings)		125.35	
Printing (circulars, notices, etc.)		114.75	
Stationery		33.20	
Stenography (Secretary, Treasurer, committees, etc.)		25.30	
Travel (Secretary to Ithaca meeting)		25.25	
Engrossing resolutions		15.50	
Stereopticon (two meetings, at $7.50)		15.00	
Floral tributes to deceased members		11.20	
Contribution toward the cost of assembling and editing international bibliography on forestry		10.00	
Telegrams		5.83	
Addressing machine (stencils, etc.)		4.84	
Refunds:			
Account sale of Proceedings	$2.00		
Account membership (associate)	1.00		
		3.00	
Protested check returned account "no funds"		3.00	
Incidentals		2.53	
			1,777.28
Balance on hand			417.75
			$2,195.03

ASSETS

Balance on hand				$417.75
Dues receivable:				
Active members:				
1913, E. O. Siecke [3]	$3.00			
C. B. Cox [4]	3.00			
1914, E. A. Braniff	3.00			
A. Knechtel	3.00			
Findley Burns	3.00			
C. D. Mell	3.00			
H. C. Neel	3.00			
W. Klemme	3.00			
E. O. Siecke	3.00			
J. H. Ramskill	3.00			
R. L. Rogers	3.00			
C. H. Flory	3.00			
C. B. Cox [4]	3.00			
D. M. Mathews	3.00			
S. D. Smith [5]	3.00			
R. Parker [5]	3.00			
		$48.00		
Associate members:				
1914, E. W. Kramer		2.00		
			$50.00	
Proceedings:				
Subscribers:				
Vol. VII (1912) University of Minnesota	$1.00			
Vol. VIII (1913) University of Minnesota	1.50			
J. S. McGrath	1.50			
Vol. IX (1914) J. S. McGrath	2.00			
		$6.00		
Miscellaneous:				
University of Montana, balance due		2.00		
Postal deposit balance		2.57		
			10.57	
Stamped envelopes on hand			30.00	
				90.57
Total assets [6]				$508.32

[3] According to present procedure, members one year in arrears have 30 days within which to make payment or be dropped from the Society.

[4] Records of the Society are faulty concerning Mr. Cox's ever having accepted membership. Have not been able to reach him during the year at least.

[5] These men accepted membership, but Secretary failed to notify Treasurer. Oversight picked up and first bills sent December 19, 1914.

[6] The constitutional amendment concerning membership effective beginning with 1914 occasioned an entire revision of the then associate membership. This revision is still under consideration by the Committee on Admissions, and no dues consequently have been collected from any of the associate members. A tentative asset on this account is placed at $40.

LIABILITIES

Dues paid in advance	$7.00	
Subscriptions paid in advance	4.00	
Bills payable, account stencils for addressing machine	.56	
		$11.56
Excess of actual assets over liabilities		496.76
		$508.32

A comparison of this year's expenditures with those of last shows an increase of $38.90 for all items other than printing and distribution of the Proceedings, which will be discussed separately. Of the two principal items—miscellaneous printing and postage—the first shows a 28 per cent decrease this year over last, while the second shows a gross increase of 120 per cent, which, however, is reduced to a net increase of 61 per cent by stamped envelopes and postal deposit assets. The decrease in printing cost is doubtless due to the discontinuance of printing and sending to all active members the full biographies of candidates and to a closer segregation of postage from miscellaneous printing as in the case of stamped envelopes and postal cards included in bill for miscellaneous printing. The increase in postage is also doubtless due in large measure to this closer segregation of postage and printing items.

No account has heretofore been taken of the stock on hand of back numbers of the Proceedings as a part of the assets of the Society. All told there are 1,550 copies on hand, besides 300 copies of the Appalachian Bibliography published as a separate. It is extremely doubtful whether these latter can be considered as an asset at all, since there is almost no call for them. It is also doubtful whether it would be justifiable to set up the entire number of copies of the Proceedings as a full 50-cent asset, since when the supply of individual numbers becomes depleted beyond a certain point the sale of complete sets will cease. These at present make up the bulk of the sales, with but an incidental call for single numbers. For the present, until the situation can be a little more closely studied, these will be valued at 75 per cent of their sale value, or $578.25.

It seems to me desirable to present at this time the financial situation with reference to the Proceedings, which has this year for the first time been issued as a quarterly publication. There were printed in all 2,500 copies—600 copies each of the first three numbers and 700 of number 4. Their total net cost to the Society, including the quarterly distribution of 2,350 copies to members and subscribers, was $1,332.49, or an average cost per copy of 53.3 cents. It was possible to bring this average cost down to this figure only by scaling down number 4 to a cost of 31.5 cents,

since the average for the first three numbers was 64.7 cents, while number 3 alone cost 66.7 cents to print.

Viewed from its most favorable side, the transaction for the year will result in a loss to the Society of but $82.50, figuring the income at the subscription price of 50 cents per copy. On the other hand, the actual receipts and assets to the credit of the 2,348 copies which went to subscribers and members (placing to the credit of Proceedings $2 out of each active member's dues and the entire dues from associate members) amount to but $1,036. Thus, after deducting from the total cost of the whole edition the possible revenue from the 152 copies remaining unsold, there is left $220.47 to be paid by the active members of the Society out of the dollar which they are assessed for the general running expenses of the Society. With but 240 active members, this represents a tax of something more than 90 cents per member.

It should be noted that all of this $220 deficit is not chargeable to the production end of the account. As near as can be determined, there have been in excess of 25 copies per quarter sent out for which no return whatever can be expected, having been sent as duplicates, and in a few cases as triplicates, to a member or subscriber, as well as to former subscribers who had ordered their subscriptions stopped. The loss on this account can be conservatively placed at not less than $50 for the year, for which the Secretary was responsible.

One other thing should be mentioned in this connection, and that is the neglect to provide a sufficient surplus of copies to meet reasonable future demands for back numbers. The extra copies available for sale of number 3, which cost over 70 cents to print and distribute, amount to a total of 13, and the same applies to numbers 1 and 2. To attempt to get out a reprint of one or two hundred copies of each, which we should have as a reserve, would bankrupt the Society, whereas an additional expenditure of less than $50 would have provided 100 extra copies of each of these numbers. We must therefore be contented with having our latest and most expensive numbers dead issues. We have 113 copies of number 4, the 31-cent issue, which should be sold for 50 cents if we are to make even as favorable a showing as we have—something it is hardly likely that we will be able to do.

Respectfully submitted,

Louis S. Murphy,
Treasurer.

The Treasurer's recommendations concerning the above matters have been referred to the Executive Committee.

Report of the Editorial Board

The Editorial Board submits the following report regarding its activities during the year and its recommendations concerning the usefulness of the Proceedings as the official organ of the Society:

The wish of the Society, as expressed at its last annual executive meeting, to have the Proceedings become a quarterly instead of an irregular publication, as it had been heretofore, has now been materialized, and seven numbers have been published on this basis. During the year four issues, containing 553 printed pages, have come out. There have been several changes introduced in the appearance of the Proceedings and a new Department of Reviews has been inaugurated. The reviews are confined to books or periodic literature which mark some new original thought. These reviews are prepared by experts in the subjects which the particular book or article treats, signed by the full name of the author, and are more of the nature of essays than reviews. No attempt is being made to cover all of the forest literature.

The Editor, by securing the expert and sympathetic help of Mr. Ballard in proof-reading, has been greatly relieved of much of the routine work in preparing the copy for the Proceedings. Judging from the expression of opinion by a number of members, the Proceedings has shown marked improvement, for which, however, the Editorial Board can claim only a small share of credit. If the Proceedings has improved in contents it is only because the members take a more active interest in it, because the profession becomes maturer, and because there are more foresters who give serious thought to forest problems and take time to discuss them in the organ of the Society. The improvement of the Proceedings, therefore, does not reflect so much the efforts of the Editorial Board as the general development in the forest profession, which is a hopeful sign and indication of a healthy growth of our Society.

With the Proceedings becoming a quarterly publication, the question of financing it should be considered. The cost of the Proceedings, including printing, proof-reading, postage, envelopes, and miscellaneous expenses, amounted to $1,382.53. The subscriptions and sale of the Proceedings brought in $781.26, the remaining $601.27 being covered by the annual dues of the active members. The average cost of a copy of the Proceedings was 53 cents, while it was sold for 50 cents. As long as the Proceedings appeared at irregular intervals—only two, or at most three, times a year—and did not form a heavy drain upon the finances of the Society, its cost did not require very serious consideration.

Each number of the Proceedings is issued in 600 copies. Some of the issues, like No. 3 of Vol. IX, are entirely sold, indicating that the Proceedings are not published in sufficient number.

The Board makes the following recommendations:

1. The Society should set a definite budget for covering the cost of issuing the Proceedings. This budget should be a definite sum; for the present, not over $1,400 and not less than $1,200.

2. The Proceedings should be published in 800 copies per issue instead of 600.

3. The honorary members should receive the Proceedings free; the Editor should be allowed 20 copies of each issue for complimentary copies and exchange. The cost of these free copies, as well as those which will remain above the present needs, should be included in the cost at which the issues are to be sold. The unsold issues will then constitute a future asset of the Society.

There is now before the Society a plan for amalgamating the Proceedings with the Forestry Quarterly. Since this is a matter which must come before the whole Society and the Executive Committee, the Board refrains at present from expressing an opinion.

Proceedings
of the
Society of American Foresters

Vol. X — APRIL 1915 — No. 2

CONTENTS

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The Proceedings of the Society of American Foresters appears quarterly—in January, April, July, and October. It contains papers delivered before the Society at its regular meetings, and original contributions by both members and non-members of the Society.

Papers that have already appeared elsewhere will not be accepted for publication. Simultaneous publication in another journal will not be agreed to.

Manuscripts may be sent to any member of the Editorial Board and should be clearly typewritten and in suitable form for printing without essential changes. Footnote references should be complete, including year of publication.

The Editors reserve the privilege of returning to the author for revision approved manuscripts and illustrations which are not in proper finished form for the printer, or, if the author so desires, the Editors will have the manuscripts and drawings prepared and charge the author the cost of this work.

Illustrations will be used only when absolutely necessary and will be confined largely to text figures or diagrams of simple character. The Editors, at their discretion, may call upon an author to defray the cost of his illustrations.

Since the membership of the Society is scattered throughout the United States and the nature of the field work of its members takes them often to remote and inaccessible places, in order to secure prompt publication no proof will be sent to authors unless requested. They are urged, therefore, to submit their manuscripts in final form and the Editors will exercise care in seeing that copy is followed.

The author receives only one free copy of the number containing his contribution. Reprints, however, can be secured at cost.

As an author may not see proof, his request for reprints should reach the Editors before his paper goes to press and should preferably be attached to the first page of his manuscript.

Missing numbers will be replaced without charge, provided claim is made within thirty days after date of the following issue.

CHARLES EDWARD BESSEY

Charles Edward Bessey

At the open meeting held on April 8 the following resolution was adopted by the Society regarding Professor Bessey's death:

In the death of Prof. Charles Edward Bessey the Society of American Foresters has lost one of its oldest and most distinguished associate members and the cause of forestry one of its earliest advocates and workers.

While Professor Bessey's main achievement lies in the field of botanical research, and while he will go down in the history of botany as one of its greatest teachers, his influence in molding the new profession of forestry and the impress which he has left upon its development will be deep and lasting.

It was only through Professor Bessey's clear understanding of the coming importance of forestry and his untiring efforts as an administrative officer of the University of Nebraska that in 1903 a forestry department was formed in a treeless region when only a very few colleges, even in wooded regions, had yet had the temerity to consider seriously the value of a professional forest school.

Professor Bessey remained until his death the moving spirit of this school, which, largely through his labors, sent out professional foresters and plant ecologists with a training peculiarly valuable to the advancement of scientific forestry in this country.

The greatest monument to Professor Bessey's scientific intuition and broad practical perception must be the forests of the sand-hills of Nebraska, which, like the Pyramids, will stand when all of us have passed. No longer a dream, but a successful realization, the greatest credit for the idea of reclaiming the unproductive desert of western Nebraska must be given to him who was courageous enough and confident enough to conceive and initiate what seemed then to be a doubtful venture.

It was Professor Bessey who, in 1890, urged the first planting by the Division of Forestry, which resulted in the successful "Bruner" plantation of jack pines. Throughout the entire period of this undertaking, from 1901, when the Bureau of Forestry made its first critical examination of the unfriendly sand-dunes, to 1910, when success at last was assured, it was Professor Bessey's sound advice and firm confidence in the outcome which instilled new faith, new ingenuity, and new effort into those who sought his counsel when their courage failed them in the face of the disheartening difficulties. The instinct which guided him in this

far-sighted work is a wonderful evidence of his unerring scientific mind. When once some one remarked to him the occurrence of bearberry on some of the more favorable slopes of the sand-hills, he said: "That has been one of my foremost guides in urging this sand-hill planting. I never saw the bearberry growing where yellow pine did not or could not grow." His power of observation had not failed him. Where not long ago only the humble *Arctostaphylos* grew, the forester today stands among lusty pines, with bared head, in reverent memory of him whose goodness and wisdom brought forth a thriving young forest from what had been a desolate waste.

John Murdoch, Jr.

On January 29, John Murdoch, Jr., an active member of the Society of American Foresters, was killed in an accident at Randolph, Mass. As an assistant forester in the Massachusetts service, he was supervising the moving of a logging camp when one of the shanties which was being mounted on wheels fell over on him and crushed him.

Mr. Murdoch was born in Boston in 1884. He was a graduate of Harvard College with the degree of A. B., in 1906, and the Harvard Forest School with the degree of M. S., in 1907. In college he received high honors, being a member of Phi Beta Kappa and obtaining his degree Magna Cum Laude.

On graduating from the forest school he became a forest assistant in the U. S. Forest Service, going first to the Sierra Forest, from whence he was transferred to the Black Hills, and then to Wagon Wheel Gap Experiment Station. In the spring of 1912 he resigned from the Forest Service and took a position with the Massachusetts State Forester. He was at first engaged in investigations covering the chestnut-bark disease, and later was transferred to the moth division, where he had been engaged in moth forestry work for the past two years. While with the Massachusetts Forester he was the author of two bulletins, entitled "The Chestnut Bark Disease in Massachusetts" and "The Chestnut in Massachusetts."

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PRESENT CONDITION OF APPLIED FORESTRY IN CANADA

BY H. R. MACMILLAN

Contributed

The individual Canadian is even more interested in the application of principles of forestry to the management of timber lands than is the individual citizen of the United States. The manufacture and marketing of forest products is of greater relative importance in Canada than in the United States. The estimated total value of the forest products of Canada was for the year 1912, $182,300,000, or an annual wealth production of $25.68 per head of population. The total value of the forest products of the United States is, of course, much greater than the total for Canada, being estimated at $1,280,000,000 for the year 1908; but the annual wealth production per capita in the United States is only $13.70. The forest as a source of wealth and a support of industries is almost twice as important to the Canadian as to the American.

From the earliest days of settlement the forest has played a very important part in the foreign trade of Canada. In 1913, 12.1 per cent of the total exports were of forest products, the value for the year being $5.97 per head of population; in the same year in the United States the products of the forest constituted only 6.3 per cent by value of the total exports of that country, averaging $1.37 per head of population.

The Canadian public meets a large share of its expenditure with revenue derived directly from the sale or leasing of cutting rights to publicly owned timber lands and from royalty and stumpage payments made upon timber so cut. The revenue derived from this source in 1913 totaled

$7,700,000, exclusive of taxation on privately owned timber lands or mills, slightly over $1 per head for the entire population of the Dominion. This is a very large revenue to be derived directly from forest lands by a community containing no more people than the State of New York.

The prominence of the forests in the industries, trade, and the public finance of Canada is in no way due to the precocious development of forest industries at a rate disproportionate with other industries. Neither is it due to the rapid exploitation of timber upon lands which later will be devoted to agriculture or other uses.

The forest plays an important part in the life of Canada because the forest offers the only important source of livelihood over an overwhelming proportion of the land area of the country. Omitting the Northwest Territories, which comprise the whole land area north of the 60th parallel, a subarctic region of 1,242,224 square miles, which cannot for many years become even an unimportant source of timber, the total area of Canada is 2,487,441 square miles. Of this total, 1,524,000 square miles, or 61 per cent, may be classed as valuable chiefly for the production of forest crops. It will be many generations before the remaining 39 per cent is devoted exclusively to other uses than the growing of timber.

It could confidently be expected that any community which depended to such an extent for its livelihood, trade, and public revenue upon any resource as Canada does upon the forest would, from financial consideration, take early measures to assure the careful protection and permanent productive capacity of that resource. While Canadians may claim to be pioneers to two of the essentials of State forestry, retaining title and timber land and undertaking fire protection, they cannot claim to have grasped the problem seriously and taken advantage of their early lead by recognizing timber as more than a temporary crop and endeavoring to administer the absolute forest land for another crop of timber.

The public lands of Canada are owned and administered in part by the Dominion government and in part by several of the provinces. The present status of forest administration can be understood only after a discussion of the six important timber administrations.

The Dominion government owns and administers the remaining public lands of the provinces of Manitoba, Saskatchewan, and Alberta, together with an area of 19,000 square miles in British Columbia. The total area so administered was originally 778,000 square miles. In accordance with principles holding good over Canada, no lands known to be timbered were ever sold or allowed to be homesteaded. In this part of Canada settlement on timbered lands has not been attractive so long as prairie could be secured, and this fact, in conjunction with an inspection of home-

steads before the issuance of patents, has prevented the taking up of any important areas of timber land by settlers. Up to the present 250,000 square miles of Dominion public lands (as these are known) have been alienated. Of the remainder, 125,000 square miles, part of which is wooded, is estimated to be agricultural. The remaining 400,000 square miles is non-agricultural land still owned by the Crown. The jurisdiction over this land is divided between an organization without forest ideals and an organization with forest ideals. The latter and more modern and progressive branch of the service is fortunately securing each year a greater control. The whole area was originally administered by a timber branch, an organization for policing the timber resources. Lumbermen or speculators desirous of securing the right to cut timber explored the country, applied for such tracts as they desired. These tracts were put up for sale; the highest bidder secured a license to cut timber, renewable in perpetuity so long as he paid the annual rental of $5 per square mile. The holder of this license is not required to cut. The duties of the timber branch are confined to the work of selling the timber, the prevention of trespass, the checking up of the quantities of timber cut, and the collection of the royalty reserved upon the timber and payable when it is cut. This royalty is 50 cents per thousand feet on all classes of lumber and may not be changed. The officials of the timber branch now cruise tracts of timber before putting them up for sale and set a reserve price, which is a protection to the public in cases of lack of competition.

The license which the purchaser acquires contains certain conditions which give the government the right to take all steps necessary to control or regulate the logging operations for the purpose of producing another crop of timber and insuring complete utilization. These provisions, which make effective forest management legally possible, are at present a dead letter because the enforcement is left to the timber branch, which takes little or no interest in this aspect of forest administration. A feature of these regulations is a provision forbidding the cutting of any timber less than 10 inches in diameter. This regulation is not uniformly enforced. It is almost without exception unsuited to the types of forest occurring on Dominion forest lands and to the methods of logging which must be practised where the average stand is not over 4,000,000 feet to the square mile. The staff of the timber branch consists of clerks and 12 to 20 forest rangers and cruisers, whose duties are chiefly police duties.

The scarcity of merchantable timber in the 400,000 square miles of wooded Dominion lands is reflected in the comparatively small area—8,342 square miles—upon which rights have been granted for the cutting

of timber. Because of the inaccessibility of these timber lands and the low grade of the product, which can be sold only when both markets and transportation are good, the annual cut is very small, being 385,000,000 board feet for 1912.

During the last fifteen years there has grown up in the Department of the Interior, which administers Dominion lands, a forest branch—the pioneer Forest Service of Canada. The first work of the forest branch was the growing and distributing of nursery stock for planting on wind-swept prairie farms. This work has grown rapidly and successfully. A study has been made of the care and development of the tree species suitable to the prairie. Two large nursery stations have been developed, and altogether 25,000,000 trees have been furnished for farmers' woodlots and shelter belts.

The forest area on Dominion lands has suffered more severely from fire than any other in the Dominion; probably nine-tenths of the total acreage has been burned over during the past sixty years. The timber branch took no responsibility for fire protection. The forest branch since its inception has endeavored to build up a fire-protective organization commensurate with the problem. The fire-protective situation is one of the most difficult which the world affords. The provincial laws under which the work is carried on afford little or no support. The hazard is widespread over thousands of square miles, the forest is in dry seasons extremely inflammable, the population is sparse, the transportation facilities are very poor, and the public sentiment, as expressed by the ex-premier of one of the provinces, is the familiar one of "get the timber out of the road." The territory is too big for expenditure on permanent improvements; there is little chance of extinguishing fires except along main-traveled roads; there is no law against the setting of fires throughout the summer for land clearing, therefore educational and police work alone is possible. This is attended to by a staff of 130 temporary rangers employed each summer and working under direction of about 15 permanent fire rangers. The average area of forest land to each forest guard is 3,000 square miles. As a matter of fact, the guards are concentrated in the regions of greatest hazard; there are many areas as great as 10,000 or 20,000 square miles where fires occur and there are no forest guards.

The forest branch has been steadily engaged in classifying lands in advance of settlement, with the object of setting aside non-agricultural lands as permanent forest reserves. Already 27,931,482 acres of forest reserves have been established by act of Parliament and may be changed only by act of Parliament. The examination of lands is still going forward and the area of forest reserves annually increased. Any agricul-

tural areas which may be included within forest reserves are not open for settlement.

Though the forest branch undertakes fire protection on public timber lands outside the forest reserves, whether held under timber lease or not, it does not administer any lands outside forest reserves. The forest reserves are chiefly burned-over lands and contain very little timber, not more than 2½ billion feet. The greater part of what they do contain is held under timber licenses acquired previous to the establishment of the forest reserves and not under the administration of the forest branch. The reproduction on the forest reserves is as a general rule good, chiefly lodgepole pine, aspen, and jack pine. The administration of the forest reserves up to the present has consisted of fire protection and the prevention of trespass. A staff, organized after the pattern of the U. S. Forest Service, is being organized. An inspector has charge of the reserves in each province; a supervisor is in charge of each reserve, the unit varying from 100 square miles to 7,500 square miles. The field work is carried out by the supervisors, rangers, and forest assistants. There is a movement under way, as yet unsuccessful, to place the forest branch under the Civil Service Commission, which will result in appointments and promotions being made for merit.

Very little timber is cut from Dominion forest reserves. The total cut in 1912 was about 7,000,000 feet, one-half of which was cut by settlers and the other half by timber operators. The total timber revenue of the forest reserves was in 1912 $21,000.

The chief duties of the staff are fire protection, administration of grazing (there is fine summer range), supervision of small cuttings, and the introduction of more valuable species. For a generation at least the expenditure must greatly exceed the revenue from timber. Though the region will not be a national source of timber, the expenditure is justified if it assures a cheap supply of timber to the important prairie farming region.

The Dominion Railway Commission is another branch of the Dominion government with administrative duties affecting forest administration. There are 29,300 miles of railways in operation in Canada, of which about 10,000 miles operate through forest country. The Board of Railway Commissioners have drawn up an effective set of regulations, requiring railway companies to keep the right of way free of inflammable material, burn only certain grades of fuel, patrol the right of way according to a schedule fixed by the board after field inspection, maintain locomotives in a non-fire-producing condition, actively fight fires which may occur. The board has placed the field administration of this order

in the hands of the administrative branches of the various governments interested and employs a chief inspector to supervise the work. As a result of this system fires starting from railway rights of way are no longer a serious menace. Few fires start, and those which do start are promptly controlled. The railway companies have by this order to appoint special officers to look after fire protection.

Ontario is one of the most important forest provinces of Canada. The area of the province is 407,000 square miles, of which 260,000 is fit for no other use than growing timber. A large proportion of the land classed as potentially agricultural land is still covered with forest.

The policy of administering timber lands in Ontario has not changed greatly in thirty years. The lands, timbered and non-timbered, are administered by a Crown Lands Department, consisting of an office staff, a number of district Crown timber agents' offices, employing cruisers, forest rangers with police duties, scalers, and fire rangers. The department employs a provincial forester and assistant, who have no administrative duties.

All public lands in Ontario are wooded, the stand depending upon the degree to which it has been burned. The public lands are open both to purchase by timber operators and speculators, homesteaders and land purchasers. Neither the settler nor land purchaser is allowed to acquire title to valuable bodies of pine timber.

Settlers and land purchasers are not taking up important areas of timber lands in Ontario. There is no classification of land by the government to prevent settlers or land purchasers taking up non-agricultural lands to the detriment of the community.

The system of handling public timber is simple. Cutting licenses are sold, which entitle the holder to what are apparently perpetual cutting rights over the area purchased upon payment of $5 per square mile rental, and a royalty, payable when the timber is cut, which varies from 50 cents per cord in the case of pulpwood to $5 per thousand on some recent sales of white pine. These licenses are sold by auction; the person willing to pay the highest cash bonus secures the license. There are at present 17,519 square miles of licenses held chiefly for white pine and pulpwood. The amount of timber cut from these licenses was 360,000,000 board feet of pine, 64,000,000 board feet of other timber, and 131,000 cords of pulpwood.

The sale of timber on public lands in Ontario is unaccompanied by any thought of the permanent productivity of the forest. No study is being made of the forest lands to learn their productive capacity; no restrictions are placed upon cutting operations to even encourage close

utilization or bring about conditions conducive to forest reproduction of any kind. The white-pine stands are treated as mines, from which a certain amount of ore is extracted each year. The quantity of pine remaining on government lands is estimated at 12 billion board feet. The quantity on licensed lands, while unknown, is probably at least as great. The quantity of pulpwood remaining is enormous. No forest survey has been made of the province.

Forest reserves covering nearly 21,000 square miles have been created. The object is to hold certain valuable bodies of timber for sale, to create recreation parks or perhaps, in accordance with the idea which once prevailed in New York State, to create a forest "reserve" for the future. The forest reserves receive no administration beyond policing and fire protection.

Ontario was a pioneer in fire protection. At present large sums of money are spent. The government employs fire rangers on the forest reserves, along railways, and on certain public timber lands carrying valuable stands of timber; 565 were so employed in 1913 at a cost of $233,000. Holders of timber licenses are required to employ men to protect their licenses, and the government supervises their work. License holders in 1913 employed 350 men. Logged-over lands, thousands of square miles of white pine, and other reproduction on non-agricultural land secure no protection. The expenditure of money is restricted to the merchantable crop. Studies made by the Commission of Conservation have shown that the province is losing millions of dollars annually by failure to protect the young growth on white-pine lands, which are even now in the center of markets. Adjoining a densely settled portion of the province 260 square miles were burned over out of a total area of 2,100 square miles in 1913. The province rarely hires men to fight fires and rarely prosecutes for infractions of the fire law. The annual loss from fire would prove staggering if it were investigated.

Though no attention is paid to maintaining a forest cover on public timber lands which are being deforested, the provincial forester is carrying on planting operations on abandoned farm lands which the government has acquired in old settled portions of the province; 1,500 acres of land have been acquired and are being reforested; 2,000,000 forest-tree seedlings have been distributed to farmers and others for woodlot improvement. The public of Ontario received a direct revenue of $2,127,000 from timber in 1913. The expenditure on the administration and maintenance of this resource was $398,000.

Quebec.—Quebec is now the largest province in Canada. The total area is 707,000 square miles, of which 530,000 square miles is valuable only for the growing of timber.

Almost the same system of public timber-lands administration has been followed in Quebec as in Ontario.

The policy of the government has been to retain ownership to timber lands. Many years ago when this policy was not in effect several million acres of timber lands passed into private hands. This was in recent years swelled by the taking up of timber land under homestead for the timber value. In order to prevent this as far as possible, a blanket forest reserve, covering 162,000 square miles, has been placed on unalienated forest lands.

Timber is sold in the same manner as in Ontario. Licenses to cut are sold at public competition by the Crown Lands Department. The licenses are perpetual; the annual rental is $5 per square mile; the royalty, payable when timber is cut, varies from $2 per thousand in the case of white pine and hemlock to $1.05 per thousand in the case of spruce, hemlock, and balsam. There are now about 70,000 square miles of timber held under license. The annual cut from licenses is about 900,000,000 feet.

Since 1906 a Forest Service has been in process of development in Quebec. Though the Forest Service has nothing to do with the sale of timber land, it performs an important work in the inspection of logging operations. Licenses issued to timber purchasers by the Crown Lands Department now carry restrictions requiring clean logging, and specify diameter limits of 13 inches for pine, 12 inches for spruce, hemlock, maple, and birch, and 8 inches for balsam and swamp spruce, below which trees may not be cut. Though these diameter limits are the same for each species over the province and are based upon insufficient data, they indicate a desire on the part of the government to handle the timber lands in such a manner as to increase their productivity. There are no regulations requiring slash disposal.

The classification of land is now a part of the duties of the Forest Service. As a result of this classification non-agricultural lands are being held for permanent forest purposes and timbered lands are protected against fake entry. No special administration is provided for forest reserves.

No general reconnaissance of the forest is being undertaken. Some work of an exploratory nature is in charge of the Forest Service. The government has not yet interested itself in the comparatively large areas of timber under private ownership.

Forest-fire protection in Quebec, except along railroads, is practically confined to timber at present merchantable. The holders of timber licenses are required by law to patrol their holdings at their own expense; 514 men were so employed in 1913. The government spends $24,000 a

year on a general supervision of fire protection. This amount is, of course, hopelessly inadequate. The public lands have suffered and still suffer terribly from fires. Fire protection is under the control of a special branch of forest protection.

The more important license holders have formed co-operative fire-protective associations, and are working out very effective plans for fire protection, putting in trails, telephones, lookouts, and protecting all timber under their jurisdiction.

Several large pulp and paper companies in Quebec are undertaking forest management on their holdings, making forest studies, cutting with a view to a future crop, and making experimental plantations.

The provincial government has started a nursery for the planting up of denuded non-agricultural lands. Small local forest reserves are being created, including the non-agricultural lands, in more densely settled areas of the province.

The forest revenue of Quebec for the year 1913 was $1,500,000. The expenditure on the forests was $122,000.

New Brunswick.—The total area of New Brunswick is 28,000 square miles, of which 20,000 square miles is fit only for the protection of timber. About one-third of the absolute forest lands have passed out of the hands of the province in the form of railroad grants or lands taken up by purchasers and settlers.

The public timber lands are administered by the Crown Lands Department, the field staff consisting of a superintendent of scalers, chief lumber scaler, and chief fire warden.

The principles followed in the administration of the remaining lands are much the same as in the provinces already discussed. The exploitation of timber has, however, gone further. White pine, once plentiful, has been cut out and the lumber industry now depends on spruce. Practically the whole of the merchantable timber has been taken up by holders of perpetual licenses to cut, which cover 10,147 square miles; 280,000,000 board feet of timber were cut from Crown lands in 1913. The rental per year for timber licenses is $8 per square mile. The royalty on timber varies from $1 per thousand for hemlock to $1.50 for spruce, pine, tamarack, and cedar.

It is felt by the government that the quantity of timber cut each year from public lands is in excess of the annual growth. No studies have been made, however, to determine this fact.

Though there is no systematic classification of lands for the purpose of creating permanent forests, the government is evidently endeavoring to restrict settlement on alienation to agricultural lands, so as to hold non-agricultural lands for the production of timber.

There has been no forest survey or reconnaissance of the province. A law has been enacted by the legislature providing that such a survey shall be completed by 1917. It has not yet been begun.

The regulations under which the licenses to cut are issued require that all slash shall be lopped; that stumps be cut low; logs cut to a 5-inch limit in the tops, and that no spruce or pine trees be cut which will not make a log 16 feet long, 9 inches in diameter at the top. This top diameter limit is reduced to 7 inches for balsam. No supervision is provided beyond that of the scalers, of whom there are about 29 for the whole area of Crown lands, and who are responsible as well for all prevention of trespass and the scaling of timber.

The forest lands in private ownership are receiving no special care.

Fire protection in New Brunswick is chiefly an auxiliary service dependent upon government and local municipal officials, whose duties are to call out the population and extinguish fires or to arrest offenders. The province appoints a chief fire warden, with supervisory duties, but does not maintain a patrol force, nor does it require the holders of timber licenses to protect their timber or contribute toward its protection. The fire loss in the past has been very heavy. The sentiment of the people toward fire protection is excellent.

The forest revenue of New Brunswick was $662,000. The expenditure on the forests was about $35,000, which is not sufficient to keep the forest areas of the province in condition to provide the revenue now received.

Nova Scotia.—Nova Scotia is the one province in Canada where the timber lands have all passed into the hands of private owners. The total area of the province is 21,000 square miles, of which only a little over 4,000 square miles is suitable for other uses than the growing of timber. Only 2,200 square miles still belong to the province. The timber in this area is leased at 80 cents per acre per year.

The government, awake to the depletion of the forest resources, has had an exhaustive survey made of forest conditions. The survey shows at the most 20 years' cut of timber still remaining on government and private lands combined. The larger owners are skinning the land; the smaller owners are endeavoring to cut somewhat conservatively. The conditions in leases on public lands giving a minimum diameter limit of 10 inches has no appreciable effect on the situation.

There are at present no regulations affecting logging on privately owned land.

Fire protection is left to municipal officers. There is no organization maintained by the government and no requirement of fire protection affecting private timber owners. The sentiment of the people is good, but the forest areas have suffered and still suffer very severely.

Legislative provision has been made for a provincial forester, but none has been appointed.

British Columbia.—British Columbia is believed to contain over one-half the merchantable timber in Canada. The area of the province is 355,000 square miles, of which 300,000 square miles is valuable chiefly for the production of timber.

Everything pertaining to the administration, protection, and study of the forest lands of the province is by the Provincial Forest Act placed in the care of the Forest Service. The head office organization consists of the chief forester, responsible to the Minister of Lands, and four assistant foresters, who have charge respectively of the offices of management, operation, records, and reconnaissance. The office of management is responsible for timber sales, land classification, forest studies, supervision of logging operations, timber scaling, and markets. Operation includes fire protection, grazing, and personnel. The records office, as its name implies, is the fiscal center and takes charge of office affairs. The division of surveys has in charge the forest survey of the province. These five officers are constituted by legislation the Provincial Forest Board, an administrative body having jurisdiction over all forest matters.

The province, for administrative purposes, is divided into 11 forest districts, each in charge of a district forester. The field staff in each forest district consists of forest assistants, permanent rangers, scalers, and cruisers. The total permanent staff in the province is about 150—a very small number for the amount of work to be transacted. The district foresters are selected from the forest assistants, rangers, and other subordinate officers. The forest assistants are at present selected without examination. As soon as candidates become more plentiful an examination test will be imposed. The rangers are selected from scalers, cruisers, and forest guards. The rangers are required to pass examinations in scaling and cruising to secure permanent positions. Scalers and cruisers are required to pass examinations and field tests before securing appointments.

The various branches of work undertaken by the Provincial Forest Service can be discussed only briefly.

One of the first and most important duties was to ascertain the facts concerning the timber areas of the province. From 6 to 12 parties have been at work during the past three field seasons. The co-operation of the Dominion Commission of Conservation has been secured. It is expected that the work will be finished in a preliminary manner in another year. At the present time it can only be said that it appears that there is more timber of a merchantable size in British Columbia than has been

usually credited to the province. All timber is, of course, being estimated whether in private ownership or not.

The only method of securing the timber on any of the public lands in British Columbia is by purchase from the Forest Service. Before the creation of the Forest Service about 20,000 square miles of timber had been alienated. The amount of timber remaining on unalienated lands is as yet unknown; it is probably one-third of the total in the province.

Up to the present the Forest Service has received application for 308 timber sales, carrying about 400,000,000 feet of timber. The areas applied for are cruised under the direction of the district forester, by forest assistants, or rangers. The principles are the same as are followed in the United States Forest Service. An upset price is fixed upon each species, depending upon its value in the tract examined; the timber is sold by public competition to the highest bidder. The timber-sale contract which the purchaser must sign, and for which he deposits a cash guarantee of fulfilment, provides that a specific quantity of timber be removed each year; that the bush be handled according to the special clauses inserted for each sale, and that fixed standards of utilization be adhered to. The standards of utilization are based upon the work of the best loggers in the district and are planned to reduce loss in stumps, tops, broken timber, or scattered logs. The brush disposal is varied on each sale, the aim being to reduce the fire hazard and to encourage valuable reproduction. The greater part of the sales has been in types where clean cutting and broadcast brush burning have been satisfactory. Very few sales have been made in types where selection cutting was practised.

There has been in effect for nearly 20 years a law forbidding the alienation of public land which averages over 8,000 feet of timber per acre west of the Cascades and over 5,000 feet per acre east of the Cascades. The object of this law is to retain for the public benefit the value of the timber on such land. The examination of public lands to prevent the evasion of this law by land purchasers and pre-emptors has been an important work of the Forest Service. Areas of public lands which are discovered to be timbered are reserved by the Lands Department, and no alienations are made within the boundaries of such areas unless the applications are reported favorably by the Forest Service. In the regions where timber lands are scattered, and it is not feasible to declare the whole area under reserve, the separate applications for pre-emptions are referred to the Forest Service for examination and action is taken on the recommendation of the Service. This practice is working out to the great advantage of the province by preventing fraudulent alienation of timber and by protecting *bona fide* settlers from locating on lands upon which they would not be successful.

The administration of the 20,000 square miles of alienated timber referred to above is in the hands of the Forest Service. Though this timber has been to a certain extent alienated, the public still retains a great interest in it. The alienations are of three kinds—6,000 square miles of Crown granted or patented lands, 1,500 square miles of leased lands, and 14,000 square miles of licensed lands.

In the greater portion of the Crown-granted lands the public retain a royalty interest in the timber amounting to 50 cents per thousand feet, payable when the timber is cut. This royalty is collected by the Forest Service. These lands are also cruised to provide a basis of valuation for taxation purposes. The Forest Service now undertakes their work on behalf of other government branches. The Forest Service has no authority to regulate cutting operations on Crown-granted lands, but has authority, which has been exercised, to require owners of Crown-granted land to remove at their own expense logging slash, which constitutes a fire hazard.

Leased timber lands are subject to the control of the Forest Service, and though the leases were issued prior to the Forest act they are subject to the Forest act or any of its amendments or any regulations issued under the Forest act. Licensed timber lands are similarly situated.

One of the chief duties of the Forest Service is the supervision of logging operations on licenses and leases. This supervision is directed toward the prevention of trespass on adjoining public lands, the collection of rental and royalty, the scaling of timber, the prevention of waste in logging, and the disposal of logging slash.

All logging operations are inspected at frequent intervals by rangers and forest assistants. The number of operations is so great—900 in normal times—that it is not economical to keep a man on each one. Cases of trespasses receive rigorous treatment. Operations are not allowed and property becomes forfeited if rentals and royalty are not paid. All timber cut or sold in the province is scaled by employees of the forest branch and no other scale is legal. A staff of check scalers is maintained, acting under the district foresters, whose duty it is to supervise the work of the scalers and to form a final court of appeal.

The effects of the campaign against waste on logging and leaving brush to form a fire hazard is being felt slowly. During the three years the Service has been in existence the lumber industry has been so demoralized that progress has been slow. It is not feasible in a democracy to enforce wholesale restrictive regulations when operators are losing money. The aim of the Service in this respect is to gradually, by constant field inspection and the enforcement of simple regulations, raise

the standard of logging to that set by the most progressive and careful operators.

The rental on timber licenses is so high—$140 per square mile per year west of the Cascades and $100 east of the Cascades—that the logged-over lands revert to the government. It is a condition of the leases that the lands revert to the government when the timber is removed. These logged-over lands are examined by the Forest Service. The non-agricultural lands are held for forest purposes and the agricultural lands are opened for settlement.

The existing legislation provides that the royalty on timber cut from leases and licenses shall be increased as the average wholesale price of lumber increases. The administration of this legislation is a part of the work of the Provincial Service.

The present work of the Service naturally suffers from lack of knowledge of forest conditions. As rapidly as the staff can be secured and trained research work and studies are being undertaken. This branch of the work has suffered and still suffers through the great volume of pressing administrative work which the staff must handle. As it is, a start has been made upon reproduction studies, volume tables, and a study of the habits and requirements of the various important species. Much will be learned from the timber sales already made. The Service is still, however, very weak scientifically.

The great necessity of forestry in the west coast is better markets. The Forest Service is now studying this question in co-operation with the lumbermen. It is hoped to add a branch, but this has been delayed by the war.

The Forest Service handles all fire protection in the province. All holders of alienated timber lands are required to pay 1½ cents per acre per year fire tax. An equal sum contributed by the government brings the forest-protection fund to about $340,000 per year.

Fire protection is handled in the same manner as the administrative work through the district foresters. The district foresters submit fire plans to the head office, stating how many five-months' guards and how many two-thirds' months guards will be needed for the summer. They are given the necessary allotments and select, appoint, supervise, and dismiss the men. The actual burden of this work falls on the rangers. The aim is continually to reduce the five-months' guards in order to render more money available for the short-term guards, as the dangerous fire season in British Columbia rarely exceeds two months. No fires are allowed without permits during the five-months' fire season. The Forest act gives ample authority for dealing with all fire hazards. The duty of the

guard is to patrol, issue, and supervise burning permits, remove fire hazards, hire and handle fire-fighting crews, and prosecute offenders. The guard districts are very large, from 50,000 acres up; therefore the district forester is empowered to appoint extra patrolmen in dangerous districts as need arises.

The Forest Service fights fires, no matter where they occur, on alienated lands, public lands, mature timber, or reproduction. Where private owners are responsible the cost is later collected from them. Whenever the fire season leaves any money in the fire-protection fund permanent improvements are constructed. Some 1,500 miles of trail, 500 miles of telephone, and 30 patrol launches and several ranger cabins are now completed.

Nearly 500 men were on guard duty in 1914. The advanced settlement of the province is spreading the area of the fire hazard very rapidly. It will soon be almost impossible to protect large northern areas. Fortunately the sentiment of the public is excellent. Forty prosecutions in 1914 added to the respect for fire protection. Over 3,000 fires occurred. The loss was 70,000,000 feet of timber, chiefly inaccessible at present.

No actual provincial forests or forest reserves have been set aside as yet; the whole province is under the same administration, as the Forest Service could not give any special segregated areas. As settlement increases, forest reserves will undoubtedly be created. Legislative provision for this now exists.

Grazing on public lands is now being investigated by the Forest Service in order that a system of administration may be worked out. The province possesses valuable grazing resources which are at present utilized. It is planned to administer these on a permit and leasing system in such manner as to encourage their wise development.

The forest revenue for British Columbia in 1913 was about $3,000,000. The expenditure for the same year was about $530,000. The revenue will increase as the timber industry increases. There is every hope that the policy of forest administration recently adopted by the government will result in the forest lands of the province being made annually more productive.

Canada has not yet traveled far along the road which she must travel if she is to make the most of her possibilities. That she has started along the road is due largely to the aggressive educational campaign carried on by American foresters—a campaign which has spread far beyond the boundaries of the United States and produced profound effects on other countries—and to the friendly spirit of co-operation shown by American foresters, who have time and again placed their services generously at the disposal of Canadians.

FOREST ADMINISTRATION IN THE SOUTHERN APPALACHIANS

BY K. W. WOODWARD

Delivered before the Society December 17, 1914

GENERAL CONDITIONS

One of the most interesting problems presented by the new forests in the southern Appalachians is the modifications which will be necessary in order to make the forest policy which has been worked out for western conditions fit in the East. The purpose of this paper is to attempt an answer to this question.

First of all, an understanding of the general conditions to be met is essential. Probably the most striking difference between southern Appalachian conditions and western National Forest conditions is the dissimilarity in historical development. Here land in the thirteen original States is under consideration. There are no public land surveys, and the laws with reference to mining and homesteading do not apply. But more important than these legal differences is the fact that the southern Appalachians lie adjacent to the principal industrial centers of the country. While there is some manufacturing west of the Mississippi in Nebraska and Kansas, and on the Pacific coast in Washington, Oregon, and California, the great bulk of the products manufactured in the United States come from the east central and north central States east of the Mississippi. This means that the eastern National Forests are close to markets and surrounded on all sides by a dense population. Even in the mountains themselves the number of people is two or three times that of the National Forests of the West. Roughly, the population of the southern mountains is about one-third of the average for the United States and one-thirtieth of that of the more densely settled parts of Europe. From the best figures available it is estimated that there is an average of ten persons to the square mile.

By reason of the agricultural development and manufacturing interests on each side of the southern mountains, practically all of the mountain passes suitable for railways have been pre-empted. It was necessary to use them in order to have quick communication between the densely settled portions east and west of the mountains. Hence these mountains may safely be said to have nearly all the through lines which will be built

in them. Future railroad development will consist merely in spur lines built into the mountains for the purpose of getting out some special product. With reference to roads, however, this whole region is in a very backward state of development and the future will undoubtedly see great activity in this regard. Roads are needed for the development of the mountain communities, the proper utilization of the timber, and for recreation purposes.

The most striking feature of the climate of the southern Appalachians as compared with the Rocky Mountain region, in which most of the National Forests lie, is its mildness and the heavy precipitation. As compared with the normal surface temperature of the Rocky Mountain region of 50°, the southern mountains have an average normal temperature of 55°. These figures do not, however, bring out the dissimilarity as well as the statement that the growing season in the southern mountains is seven months as compared with five months in the Rocky Mountains. The big difference between the two regions is, however, in the precipitation. In the Southeast there is an annual rainfall varying from 50 to 70 inches, while the Rocky Mountain region receives only 10 to 30 inches. In precipitation and mildness of climate the southern Appalachians are more like the Northwest, with the essential difference that there is a larger amount of sunlight and, hence, greater evaporation. A very striking feature of the mountain climate is the heavy rainfall during July and August. This results in severe erosion, since torrential rains fall at a time of the year when the soil is unprotected by cold weather. This region is, in fact, the section of the country in which more erosion takes place than in any other part of the United States. In addition to the climate being especially favorable to erosion, the deep residual soil and steep slopes also accelerate it. Mr. Zon has pointed out a further difference in that the southern mountains do not cross at right angles the moisture-laden winds the way the Cascade and Rocky Mountains do. This means that there are no such widely dissimilar climates on the opposite sides of the Appalachians as are found for example in Washington on the east and west sides of the Cascades.

While the absolute elevations in the southern Appalachians are insignificant as compared with the high altitudes reached in the West, the region is one of distinct mountains. For a distance of 650 miles in an air line from Virginia to Alabama and for a width of 40 to 60 miles, 90 per cent of the country is mountainous, and 85 per cent has a steeper gradient than one in five.

In this area, which is slightly larger than England and Scotland combined, there are 46 peaks and 41 miles of divide above 6,000 feet. Two

hundred and eighty-eight mountains and 300 miles of divide are above 5,000 feet in elevation. Probably the most striking difference between the southern mountains and the Rocky Mountains is the absence of barren tops. In no case do the mountains rise above the timber line, although on the higher peaks, like Mt. Mitchell and Clingman Dome, the timber is very scrubby. This seems to be due, however, to heavy winds rather than to too severe a climate.

Summing up the general conditions to be met, there is, in brief, a rough, sparsely settled mountain section jutting down into one of the oldest and best developed parts of the United States. The historical background and problems of development are entirely different from those of the West. Its mild climate, with the heaviest precipitation in the summer, is another factor which necessitates new methods in fire-fighting and silviculture.

FIRE PROTECTION

The first problem in the administration of the National Forests in the East was, as in the case of the western forests, the decrease of the damage from forest fires. With hardwood growth, ample rainfall, and no dry electric storms, the problem seems very much more simple than that of the West, with its scant rainfall, inflammable, coniferous forests, and dry lightning storms. Fires from lightning and top fires may be eliminated from consideration almost at the start, although there are a few small patches of spruce in which top fires might occur. The fire hazard is only great at two seasons of the year—the early spring and the late fall. With the beginning of March fires are apt to occur, and even during the normal season the spring rains are not frequent enough to do away with all danger until the green foliage is well started, by the end of April. In the fall the risk comes mainly from the piles of hardwood leaves, which are not matted down enough until the heavy rains and snows of December. While the normal fire season consists of 2½ months in the spring and 2½ months in the fall, drought may extend it throughout the winter or make fires possible even during the summer months. The fire seasons are never so clearly defined as with the dry season in the summer on the western forests.

Contrary to the general assumption that incendiary fires would be the most frequent, approximately 75 per cent of the fires which have occurred on land approved for purchase have been caused by railways. Ten per cent were due to carelessness in brush burning and the remaining 15 per cent are ascribable to incendiarism and unknown causes. With this information in hand, the main preventive measures have been directed

toward securing the co-operation of the railroads, the education of brush burners, and the dissemination amongst the general public of data showing how much damage fires do. Very gratifying results have been obtained in crystallizing public sentiment against forest fires. While the time-worn belief in favor of light burning prevails here as elsewhere, it would seem that the mountain communities had reached the stage when public opinion was ready for the leadership of the Forest Service in preventing forest fires. With the railroads the problem is less simple, since scarcely a single railway in the mountains had made any attempt to properly clear up its right of way or provide adequate spark arresters. Fortunately, however, Virginia has a most excellent fire law, and there are hopes that the State laws of North Carolina, South Carolina, Tennessee, and Georgia may force the railroads to greater precaution or be so amended that the railway companies will be compelled to take a greater interest in fire protection. While there has been fairly satisfactory response on the part of railway companies, much yet remains to be done. This is shown by the fact that during the month of November there were 56 fires on the White Top area, comprising about a hundred thousand acres, due in greater part to the three railroads crossing the government land.

The improvement work so far undertaken has had for its sole purpose better fire protection; hence the funds have been expended on trails, telephone lines, tool-boxes, and lookout towers. As quickly as an adequate trail system is provided telephone lines are built, and while there is a fairly good network of privately owned lines around the forests, the Forest Service has had to construct practically all the telephone lines within the forests. By a combination of pole and tree line, the cost of these can probably be kept below $60 a mile on the average. Trails should not exceed $40 per mile, since the difficult rock work is offset by the possibility of using old logging roads and paths. So far no ranger stations have been built and it is doubtful whether it will be necessary to construct any for a long time to come. The rangers should be expected to provide their own homes in the near-by towns. The salaries paid by the Forest Service are large enough so that no hardship will be put upon the men if this requirement is adhered to. Moreover, this policy will prevent the building of expensive cabins in inaccessible places, as was sometimes done in the early days on the western forests.

The essential natural differences to be considered in the fire problem are that while the risk is commonly much less than with the pure stands of western conifers and the long dry summers of the Rocky Mountain region, the fire season may last throughout the year if a dry summer

follows the open, mild winter. Man-made fires are due to about the same causes, both east and west. There must be the same education of the general public and constant pressure brought to bear upon the railroads. In spite of the long time the region has been settled, much yet remains to be done in the way of trail and telephone line building, even to secure adequate means of communication from a fire-protection point of view.

TIMBER RESOURCES

It is unnecessary to remind you that the southern Appalachians probably contain the largest hardwood forest in the temperate regions of either the Old World or the New World. While the Carpathians in Austria and the Argonne Forest region in northern France are similar, they do not cover the area that the southern mountains do. Taking the region as a whole, chestnut is the most abundant species, making up 50 per cent of the total stand by volume; white and red oak make up another 25 per cent; yellow pine, 5 per cent; yellow poplar, basswood, and cucumber, 5 per cent, and a number of miscellaneous species the remaining 15 per cent. These figures will show that, in spite of the poplar, hemlock, and spruce timber which is being shipped out of this region at the present time, the bulk of its contribution to the timber supply of the country must be in the hardwood species, chestnut and oak, which are so valuable for heavy construction and furniture.

One of the most striking points in reference to the distribution of timber in the southern Appalachians is the inequality of the stand. This at first seems hard to explain in a region of heavy rainfall and mild climate. Dense stands only occur, however, in the deep-soiled, moist coves. On the slopes and ridges the timber gradually becomes thinner until on the ridge tops the average stand is less than 2,000 board feet per acre, even under virgin conditions. In the coves the average stand where no lumbering has been done is 10,000 board feet per acre, while the intermediate slope type does not average over 6,000 board feet. To show the importance of the rôle which evaporation plays in decreasing the amount of available moisture, the percentages of the different types are given: Cove, 5 per cent; slope, 55 per cent; ridge, 40 per cent. With the relatively small amount of moist soil, it is easy to understand that the average stand per acre, even under virgin conditions, is only 4,000 board feet per acre.

While there is a general impression that the government has not bought anything but cut-over land, as a matter of fact, 35 per cent of the area approved for purchase is virgin timbered land. Fifty-eight per cent has

been culled and cut over; some of it, however, so lightly that its timber value has been very little depleted. The remaining 7 per cent is 2 per cent abandoned farm land and 5 per cent burnt and barren.

The average stand per acre of the tracts which have been approved for purchase is approximately 3,000 board feet, with a range from 5,000 to 5 board feet per acre. Sixty per cent of this average stand, or 1,800 board feet, is saw timber, while the remainder includes such products as poles, ties, extract wood, and pulp wood. In addition to the timber, tan bark is a valuable product in the southern Appalachians. The amount of this to be obtained from chestnut oak and hemlock varies from one-eighth to two-thirds of a cord per acre. Moreover, black-oak bark can also be used for tanning purposes and is being sold from acquired land at the present time, although no estimate was made of it as a valuable product when the land was paid for.

In view of the fact that 50 per cent of the timber now being acquired in the southern Appalachians is chestnut, the government has a very keen interest in the progress of chestnut blight. Serious infections have already occurred near the Potomac and Massanutten areas in Virginia and West Virginia. Arrangements have been made to check the spread of disease from these infections by co-operating with the State governments. The problem is somewhat complicated from the diseased trees not being on land which has been approved for purchase. Recently a new infection has been reported from the Natural Bridge Area, still farther south in Virginia. This marks the most southerly point of the disease in the southern Appalachians. Through co-operation with the State and Bureau of Plant Industry experts, exact knowledge of the appearance of the blight is given to all forest officers, and especially fire guards, in the hope that all infections will be discovered before they have had a chance to spread over large areas.

Another serious menace is the beetle *Dendroctonus frontalis.* This is normally a coastal plain species, and it is only able to thrive in the mountains during mild winters. However, it has spread as far north as southern Pennsylvania; so that its progress in the mountains must be carefully watched if a repetition of the attack in 1880 is to be avoided. At that time practically all the pine of any size was destroyed throughout Virginia and West Virginia, and the beetles were checked only by a series of very severe winters. It has already been necessary to cut out one infestation on the White Top area. Unfortunately the timber attacked was too inaccessible to be sold or given away, so that it was necessary to cut the trees down and burn them on the ground. This was done at an average cost of 30 cents a tree.

Assuming an average annual growth of 100 board feet per acre for the cove type, 60 board feet for the slope type, and 20 board feet for the ridge type, the average annual growth is estimated to be 46 board feet per acre. With better fire prevention and the reseeding of denuded areas this annual growth can undoubtedly be greatly increased. Another factor in which the density of the stand may be increased is by under-planting of tolerant species. Fortunately there are a good many such species in the southern Appalachians, which are also valuable for their timber, as, for example, beech, dogwood, holly, and hemlock.

The cost of production, including sawmilling and hauling to the railroad, ranges from \$10 to \$15 per thousand, with an average of about \$11. The value of the manufactured product at the railroad ranges from \$12 to \$35 per thousand for the mill run. Although this region has a marked advantage over the western markets with reference to freight rates, still the rates are high enough to prevent the marketing of anything but the higher grades south of Virginia. This means that relatively few of the species are merchantable in North Carolina, Tennessee, and Virginia. Generally speaking, only cherry, walnut, yellow poplar, hemlock, white oak, red oak, and chestnut can be profitably shipped from any State but Virginia. However, in spite of the impossibility of reaching the general market with low-grade material, the advantage in the way of accessibility which the eastern forests will have over the western forests is clearly shown by a comparison of the freight rates. In order to reach the general market, the cost is \$5 to \$10 per thousand from the southern Appalachians, while the western States can only reach the general market at a cost of \$15 to \$25 per thousand. Even the Panama Canal will not put them on a par. The minimum stumpage prices approved for the present fiscal year range from \$1 per thousand for the inferior species to \$8 per thousand for such valuable wood as black walnut. Naturally the maintenance of these minimum prices means that it will be impossible to make sales on the more inaccessible areas, but this is no great drawback, because there is no hurry about forcing the government timber on the market, the general market being adequately supplied from private sources of timber.

Summing up the general situation with reference to the timber resources of southeastern forests, it is seen that the government is acquiring timber which will act as a steadying influence upon the hardwood market and help to insure a permanent future supply. A mild climate, good reproduction, and a fairly good market are the favorable factors, while the mixture of species makes the silvicultural problems more difficult than those of the West.

GRAZING RESOURCES

In the woods the forage consists of shade-enduring grasses and annual herbs, which are nutritious for stock, like the pea vine. Of course, when other kinds of forage are not available, sheep and goats, and even cattle, browse on tree leaves; but if stock are kept out of the woods during the winter and early spring, there is generally little damage done through browsing. On the tops of the ridges and in the "balds," where there is no shade, a sod of blue grass establishes itself. Were these forests not intended primarily for watershed protection and timber supply, there would be a question as to whether it would be the best policy to clear the ridge tops and allow the grass to take possession, for in such cleared places the sod has a carrying capacity at least three times that of the ordinary woodland grazing.

What the proper average carrying capacity for this range should be is as yet a matter of question. The number of head authorized for the different areas varies from 10 to 200 acres per cow, with an average of approximately 90 acres. This is undoubtedly much less than the range can carry without danger of overstocking. Even the areas upon which there are the largest number of stock show no signs of overgrazing. As a tentative standard, 15 acres per cow seems to be a safe figure for the carrying capacity in the southern Appalachians, assuming that the stock, with the possible exception of hogs, will not occupy the range more than six months.

While the carrying capacity of the range can profitably be increased by such permanent improvements as watering places, drift fences, and trails, the main need seems to be more stock, if anything like thorough utilization is to be obtained. This will not be forthcoming until the farmers living near the forests build up their flocks. At the present time every farmer has a few head of cattle and hogs, and sometimes sheep, but they are nearly all for his own use, and the possibility of reaching the general markets has not yet brought about the breeding of large numbers of stock or high-grade stock. The Bureau of Animal Industry is now preaching to the southern farmer better methods of stock raising, and there will undoubtedly be a gradual increase in the number of head applying for range on the National Forests. Whether the Forest Service should attempt actively to encourage this increase is a question, because experience abroad has shown that close utilization of the range is not consistent with good silviculture. Therefore it seems better policy to let the stock industry grow naturally, always bearing in mind that it may be necessary, from the silvicultural point of view, to exclude stock

from certain areas, especially during the reproductive period. In this way there will be little danger of the growth of grazing rights, which may become a menace in the future.

Comparing eastern and western conditions, it is clear that the carrying capacity is greater in the East, but that no such extensive industry is established as in the West. While it will be many years before we will have to face problems of overgrazing, the danger of building up an industry which may interfere with intensive silvicultural management must be borne in mind, especially in a region like the East, where markets are close at hand.

SPECIAL USES

Eighty per cent of the special uses so far issued are for agricultural land. These cover small patches of tillable land similar to the areas taken up under the act of June 11, 1906, on the National Forests in the West. Probably there will be a slight decrease in the area and number of these tilled lands, because many places are now being occupied which are unfit for agriculture on account of the steepness of the slopes under tillage. A policy has been adopted of refusing to allow the permanent cultivation of patches which are less than ten acres in extent. Even these are generally too small for the support of a family. However, it may be possible for enterprising men to combine the tillage of such small patches with other work in such a way that a comfortable living is obtained. There seems to be no objection or prejudice on the part of people native to this section of the country to leasing from the government. Renting has been the common practice in the past, and so far there has been no demand for the sale of agricultural land acquired under the Weeks Law.

Compared with the West, there will be little water-power development, because private concerns have already cornered the good sites. Agricultural permits, cottage and hotel permits, promise to be the main sources of special-use revenue.

COSTS AND RECEIPTS

Where an area of more than 200,000 acres is under administration the cost of protection can be kept down to 3 cents an acre. Since few of the areas have yet obtained so much approved land, the cost on most of them is still too high. It can, however, readily be seen that with an increase in acreage the cost of protection will decrease rapidly, since the salary of the officer in charge forms a very large per cent of this cost. Permanent improvements average 1 cent per acre and the administrative work costs 2 cents per acre each year.

On areas like the Natural Bridge and the Mount Mitchell, where it has been possible to develop small sales, the income is already 6 cents an acre. Averaging together the areas which have forage, the grazing receipts per acre are 1½ cents per annum. Special uses bring in an additional one-half cent per acre, so that the total annual receipts on the more accessible areas is 8 cents. Of course, as more timber is made accessible and larger sales are made, the grazing resources are more fully utilized, and the special-use business developed, the gross income will greatly increase, and it is not unreasonable to expect that the net income will grow larger also, because, while the cost of protection, improvement, and administration will naturally increase, the difference between the costs and receipts will increase correspondingly. Compared with the western forests, the eastern will be of smaller size, more intensively managed, and yield higher revenues.

RESULTS OF FOREST ADMINISTRATION

Since the eastern National Forests were established primarily for the protection of the watersheds of navigable streams, their effect in this way should be considered first. It is unnecessary, of course, to show in any detail that the forests on the headwaters of the streams arising in the southern Appalachians will have a marked beneficial effect upon the water-power resources of the lower Mississippi Valley and the Piedmont Plateau, and the navigability of the Mississippi, Ohio, Tennessee, Savannah, Santee, James, and Potomac rivers. Secondly, these forests should act as a conservative force in steadying the hardwood market, since they will eventually form one of the important sources of supply for such timbers as chestnut, white oak, red oak, and yellow poplar.

Even at the present time, when the southern mountains are little used for recreation, people are using our trails to get into the mountains and inquiring about the possibility of renting cottage sites. Unfortunately game protection in the Southeast is in a very backward state, and until the public sees the importance of protecting the game resources it will be inadvisable to encourage much camping. However, the future is bound to bring a more rational attitude toward game protection and demands for camp sites, trails, and roads.

THE SOUTHERN MOUNTAINEER

While the Forest Service is under obligations to make these forests pay their own way at the earliest possible date, the real test of the success of our administration will be the reaction of the southern mountaineer to the work of the Forest Service. The most striking illustration of the way in which the National Forests have made good west of the Mississippi

was furnished by the replies to the inquiries which Mr. Pinchot sent out a few years ago to the users of the forest. As I remember the figures, 80 per cent of the people who actually came in contact with the Forest Service were unanimously in favor of National Forests. If, after five years of administration in the southern Appalachians, there is similar unanimity amongst the mountaineers, the southeastern forests may be said to have made good.

In spite of the hard reputation which the southern mountaineer has acquired in some quarters on account of his illiteracy and moonshining habits, he is at heart a most excellent citizen, hard-working, kindly, and loyal. Kephart, in his book, "Our Southern Highlander," has effectually laid to rest the slander that these people are merely the descendants of the colonial bond servants. He shows conclusively that the southern Appalachians were settled primarily by Pennsylvania Germans and Scotch Irish, who chose the mountains on account of the abundance of game and fish. Of course, the mountain communities have been increased in some measure by people who were forced to leave the lowlands and by what has been picturesquely described as "broken axle" men; or, in other words, men who were so discouraged by a broken axle in crossing the mountains that they were willing to settle down and give up hopes of reaching the lowlands on the other side.

That the mountaineer will succeed, if given a chance, is shown in many ways. Even moonshining is unquestionably harder work than the ordinary man is willing to undertake for a livelihood. On the trails which the Forest Service has been building in the mountains the mountaineers have worked faithfully and well. In many cases the eight-hour day enabled them to live at home and they thought nothing of putting in a good day's work and walking three miles in the morning and at night. In fact, there seems to be no question that the mountaineer is backward in his development through the lack of communication with the outside world and a chance to make a comfortable living. Now that the game has been practically exhausted in the mountains, mountain families must depend upon the few cattle and hogs they raise and the corn in their steep fields. The improvement work which the Forest Service will do and the chance to handle small timber sales will undoubtedly enable them to raise their standards of living. The experience of the Biltmore estate has shown conclusively that these people have latent ability in handicrafts, and it does not seem a far-fetched prediction to say that they have the possibility of developing their country in much the same way that the Swiss highlanders have achieved financial independence. In this work of development the Forest Service can play an important rôle by insuring the conservative use of the resources.

A STUDY OF DOUGLAS FIR SEED

BY C. P. WILLIS AND J. V. HOFMANN

Contributed

PURPOSE OF STUDY

This study, which is doubtless the most exhaustive investigation ever made along its special line, was planned by Thornton T. Munger, and is being carried out at the Wind River Experiment Station, Carson, Washington. The investigation is far from completion, for it will probably cover a forty-year period; but so much interesting data have already been secured that its publication, in the form of a "progress report," appears desirable.

The broad purpose of the study is to obtain all possible information concerning the source of seed. In particular, we wish to know from what kind of sites and from what sort of trees we should collect seed for artificial reforestation, and to know what class of seed trees are satisfactory for the natural restocking of our timber-sale areas.

The results of the study are primarily of local application in that they refer to the one tree, Douglas fir, in one part of its range, the Pacific Northwest. Nevertheless it seems that much that has been learned can be applied safely to other regions and even to other species, for the broader rules governing seed production and inherited characteristics seem so well defined and so clearly the interplay of known cause and effect that they have the ear-marks of universal laws.

METHODS OF STUDY

In the fall of 1912 cones were obtained from 127 different trees, each of which was carefully described as to its growth and site conditions. Not less than one-eighth bushel of cones was collected from each tree, and these were taken from all parts of the crown indiscriminately; so that each lot of cones was typical of the whole tree. The 127 trees represented ten different localities on the west side of the Cascade Mountains, from north central Washington to south central Oregon. The sites varied in altitude from 100 to 3,850 feet above sea-level. The aspects, slopes, and soils of the sites were likewise very variable. The trees ranged in age from 14 to 600 years, and in diameter from 3 inches

to 6½ feet. They differed in their crown development correspondingly widely, according to the density of the stand in which they grew. Most of them were healthy and vigorous, but some badly attacked by fungi (conky trees) were included for comparison.

The varying conditions of site and growth made possible comparisons such as the following:

1. Altitude, high or low.
2. Locality, northern or southern.
3. Soil, good or poor.
4. Age, young, medium, or old.
5. Size, small, medium, or large.
6. Health, good or poor because of conkiness.
7. Stand, open or dense.

The details of the cone gathering were so planned that each tree was chosen, not at random, but because it possessed one or more of the qualities which were to be investigated. It was realized, however, that individual trees might have chance variations that might obscure the effects of the factors studied, and for this reason several trees were taken for each condition. The group of trees (usually 4 or 5, sometimes 8 to 11) was really the unit of the study. The average figures have therefore good basis, even where the minima of but two groups are compared. In some instances, however, as in the case of altitude, all the 127 trees in the study were included when the averages were computed. There consequently seems no question as to the sufficiency of the data.

The personal element and the chance of bias toward this or that conclusion were eliminated by giving each lot of cones a number as soon as it was received at the experiment station and thereafter recording all information under the number. When observations were made concerning a given lot of cones, or the seed or seedlings derived from it, the observer knew nothing of the source. The original records, giving the growth and site conditions of each tree, were not referred to until the figures obtained were averaged at the end of the field seasons.

While green and unopened the cones were measured to determine their size or the "number of cones per bushel" and their quantity. The latter, together with an estimate previously made of the per cent of the crop collected from the tree, gave the "number of bushels of cones per tree."

Next the cones were dried by artificial heat in open trays in a greenhouse. After thorough drying, the seed was extracted by means of a large revolving wire drum. The total yield of seed and debris was then

weighed to determine its amount, and next was passed through a fanning mill to eliminate the chaff.

After cleaning, the seed was reweighed, to give the "number of pounds of mill-cleaned seed per bushel of cones."

A sample of approximately 1,000 seed was then weighed, next hand-cleaned, then reweighed, and finally counted. From these operations the purity of the seed and the number per pound hand-cleaned (the latter "size of seed") were obtained. The "number of seed per bushel of cones" was next computed. Cutting tests and germination tests were likewise made. The first germination test was made in the greenhouse and gave unsatisfactory results; so its figures were discarded, and in their place the germination in regular nursery beds was taken. The latter proved perfectly reliable.

Partly for the germination test and partly to afford data on seedling growth and to furnish stock for future outplanting, about 300 seed of each tree were sown in a portion of the nursery segregated for the special purposes of the Douglas-fir seed study. Where certain especially important phases were to be investigated about 1,800 extra seed were sown for a surplus stock of selected trees. From this (1913) sowing there are now growing about 250 seedlings apiece for most trees, while 2,000 seedlings are available for some trees.

To supplement the information obtained from the seedlings mentioned, the sowing was repeated in 1914, about 300 seed for each tree again being used.

The seedlings have so far yielded data as to height growth and time of bud formation. They later will give information as to hardiness and other qualities, for they will be outplanted in different localities and at various altitudes and will be observed for 40 years, if necessary. Their behavior will definitely decide all mooted questions in the study. The original number given the cones will be still used, so that we can tell with certainty the pedigree and history of every seedling planted.

THE FACTORS DEALT WITH

The following list shows the factors of the study. The influences of the factors first given, individually and collectively, on the factors in the second column were studied in detail. Not all the first column factors, however, influence all the second column ones. The detailed discussion of the results of the study will show which were involved in each particular phase, but the list shows more clearly than the discussion the general points involved.

Influence of—	*On—*
Age of tree	Yield of cones per tree.
Size of tree	Size of cones.
Growing space of tree.	Size of seed.
Health of tree	Weight of cleaned seed per bushel of cones.
Soil of site	Number of cleaned seed per bushel of cones.
Elevation of site	Germination per cent.
Latitude of site	Number of good seed per bushel of cones.
Size of cone	Number of good seed per tree.
Size of seed	Per cent of buds formed November 6, 1913.
Germination per cent.	Per cent of buds formed November 9, 1914.
Time of bud formation.	Height growth of seedlings first and second years.

Altogether 83 tables were made, to express the relationships of these factors. Many of them gave negative results, of course, but there nevertheless resulted a mass of data. This is summarized and correlated in pages which follow.

AVERAGE FIGURES FOR STUDY

Before the detailed results are presented it will be of interest to consider the average figures for all the trees studied. These are as follows:

Number of bushels of cones per tree	2.46
Number of cones per bushel	1,001
Pounds of mill-cleaned seed per bushel of cones	.41
Pounds of mill-cleaned seed per tree	1.01
Number of seed per pound mill-cleaned	38,254
Number of seed per pound hand-cleaned	40,454
Number of seed per bushel of cones	15,684
Number of seed per tree	39,637
Number of seed per cone	16
Germination per cent, 1913	65
Germination per cent, 1914	50
Number of good seed per bushel of cones	10,195
Number of good seed per tree	25,764
Height growth in inches of plants:	
First year, 1913	2.05
First year, 1914	1.50
Second year, 1914	2.62
Per cent of terminal buds formed:	
November 6, 1913	48
November 9, 1914	97
Mortality of seedlings, per cent:	
First year, 1913	3
Second year, 1914	10

FACTS CONCERNING THE CONES

The study of the cone crop is the logical starting-point of the whole investigation and will first be considered in stating the results obtained.

There are two lines of inquiry concerning the cones, the first dealing with the quantity of cones produced under different condition and the other dealing with the size or development of the cones themselves, as influenced by site or growth conditions. There next arises the important question as to the worth and direct application of the facts brought out. These phases will be taken up in their order.

The Yield of Cones per Tree

The yield of cones is affected by the age and size of the tree and by the growing space it has, and also by the altitude and latitude of the site. Conkiness of the tree and poor soil of the site seem to have no effect whatever on the quantity of cones produced, but it will be shown later that these are of material importance from other standpoints.

The increase in production as the tree grows older and larger is so clearly related to the larger crown the tree has at later stages that it would need no explanation were it not for one point: The oldest and largest trees do not bear the largest crops. The maximum production occurs at about 100 to 200 years of age, or 3 feet to 4 feet diameter, if the tree has grown rapidly. Trees of this age and size bear four bushels per tree on the average, while both very small, young trees and very large, old trees produce only one-half to three-fourths bushel. The best cone production is therefore in middle life. The vigor of production probably decreases consistently from youth to old age, but the rapid growth of the crown, affording more space for cone production, offsets this tendency until after middle age.

Open-grown trees produce larger crops than those in dense stands. In the best comparison of the study the former gave 55 per cent more than dense-grown trees. It may be that the larger crowns of open-grown trees sufficiently account for the difference, but it is probable that apart from this the greater light available also has its effect in stimulating production.

Warm localities appear to favor high production; thus trees from southern localities yielded five times as much as those farther north. Similarly low-altitude trees produced twice as much as high-altitude ones. There is so much local and yearly variation in the amount of the crop, however, that these statements cannot be taken literally, for it might

have been an off year for northern Washington and a good year farther south, and similarly in regard to the particularly high and low places from which collection was made. The tendency for large production in warm localities nevertheless appears established.

The foregoing statements may be summarized as follows: The yield of cones per tree is highest with medium-aged, rather large trees, which grow in open stands, in warm localities.

The Size of the Cones

Field observations during cone collecting led to the conclusion that the size of the cone is directly dependent upon the vigor of the cone-bearing shoot. Where the annual growth of the twigs was fast the cones were large. Where the twigs grew but little, the cones likewise were stunted. This proved true not only in comparing different trees, but also for different parts of the same tree.

The results of the study proved conclusively that the age of the tree is the determining factor in the size of the cones. Trees 15 years old had 700 cones per bushel, and trees 600 years old had 1,916 per bushel (the latter being, of course, very much smaller cones, since it took so many of them to make the bushel). Since the shoots grow very vigorously when the tree is young, the reason for large cones with small trees is clear.

Apart from the effect of the age of the tree, there was no clear influence of any growth or site factors on the size of the cones. The size, or trunk diameter of the tree, as reflecting the age factor, showed that small trees have large cones and large trees small cones; but the figures were not as consistent as those for the age classes. The quality of the soil and the latitude of the site seemed slightly effective in determining the size of the cone.

Application of Results

Though the largest crop of cones is found on medium-aged, rather large trees, in open stands, and in warm localities, it does not follow that we should collect cones from such stands, nor that we should leave large trees for seeding logged-off areas. The size of the cone crop is but one factor to consider in collecting cones, since the ease of gathering is quite as important as the quantity available. It is therefore particularly interesting that young trees have the largest cones. These small trees can be climbed easily in cone-gathering and can be left economically as seed trees if they occur on logging areas.

In this connection reference may be made to facts which will be discussed later in detail, but which are also of present interest. Just as the vigor of the cone-bearing shoot affects the size of the cone, so the latter affects the size of the seed, and this in turn affects the size of the first-year seedling. Though the advantage of size is not continued strongly in the second year's growth, still it seems that large cones are preferable to small ones, since they tend to produce bigger plants. Nevertheless small cones are satisfactory, so they need not be avoided.

Neither the size nor the appearance of the cones is necessarily indicative of the quantity of good seed yielded per bushel of cones. The only exception to this is in case the cones are infested with destructive insects, in which event the appearance is a good index, since signs of the insects may be found on opening sample cones. Cones free from insects may still be poor in having large numbers of infertile seeds.

Owing to insect attack, we have the paradox of high yield of seed per bushel of cones where the crop is usually small and low yield per bushel where the crop is ordinarily large. The insects are especially prevalent in warm regions where the cone crop is plentiful, doubtless merely because of the abundance of their food. Being abundant, they destroy much seed. If we wish to obtain a given amount of seed, we must gather more cones to furnish it, if we collect from warm localities, than if we gather from cold places. This phase should not be confused with the somewhat similar one of concentration of insect damage when the crop is small in comparison with other years in the same locality, and the diffusion of attack which occurs when the crop is large for the given locality. From all this it follows that a big crop of cones is apt to be of higher quality than a small one if years in a given locality are compared, while the contrary is probable if localities in a given year are compared.

To sum up the foregoing statements: Cones collected in cool localities are freer from insect attack than those in warm localities. Though harder to gather, on account of the smaller quantity produced, they offset this disadvantage by being intrinsically more valuable. It therefore may be best at times to collect from localities which have poor crops. A crop smaller than the average for a given locality should be avoided if practicable, since insect attack is concentrated in it. Just as large crops of cones do not necessarily indicate the locality we should collect from, so large yields per tree do not suggest that we gather from the medium-aged, rather large trees, which bear most prolifically. Young trees yield very good cones and permit of fast work in collecting, since they can be readily climbed. Similarly young trees seem satisfactory for seed trees, if they occur on timber-sale areas, since they have low market value com-

bined with good cone-bearing qualities. It is understood, of course, that more of them should be left per acre, since the yield per tree is less than with large-crowned trees.

FACTS CONCERNING THE SEED

Next to the study of the cones comes the inquiry concerning the seed. The seed was studied to determine the following points: the size, the yield of clean seed per bushel of cones, both by weight and by number of seed, the germination per cent, and the number of good seed per bushel of cones and per tree. These points will be discussed separately and the conclusions will be summarized under the heading "Application of Results."

The Size of the Seed

The size of the seed was determined by finding the number in samples of known weight and expressing the result in "number of seed per pound." The samples were first cleaned in the fanning-mill and then by hand. This method is the one commonly used, but it is not without flaws. The fanning-mill supposedly blows out a uniform proportion of the poor seeds in all lots, but in practice this perfection is not possible. If there are more wormy or light seeds left in one lot than in another, incorrect numbers are obtained to show the relative size of the seed. The limit of error is believed rather small with the careful work which was done in the study, but there is nevertheless some slight doubt; so most of the following statements are considered tentative.

The relation of the size of the cone to the size of the seed seems so well brought out that it is considered proven. The largest cones had seed running 35,000 to the pound, and the smallest gave about 57,000 to the pound. There are variations, however, which suggest that other factors besides the cone size may enter into the question.

With age and size of the tree, and particularly with the former, there is the relation brought out in the discussion of the cones, viz., young trees have large seed and old trees small seed, because the vigor or slowness of the shoots growth is transmitted to the seed through the cone growth. Trees 15 years old had seed running 35,000 to the pound and trees 600 years old had 53,000 seed per pound. Trees under 6 inches diameter had 36,000 seed per pound and those over 6 feet diameter had 48,000 seed per pound.

The figures of the study show that open-grown trees have larger seed than forest-grown trees; that larger seed are produced on good sites than

on shallow, gravelly soil, and that southern localities yield larger seed than northern ones. These statements are not doubted, but they cannot be considered absolutely proven by the study.

No effect of serious conkiness of the tree shows in the size of the seed, nor can the effect of latitude be seen in the results. The latter is surprising, in view of the seemingly clear effect of altitude. The largest seed was apparently that of the highest altitude, but this is explainable by the greater number of wormy seeds at low altitudes, which were partly included in the samples through imperfect cleaning in the fanning mill. If there are a number of wormy or light seeds in the samples, there are more seed counted per unit of weight than should be and the number of seed per pound is too high. This means that the size of the seed obtained for low altitudes probably is smaller than the correct figure. This chance factor may have obscured the larger size of the seed at low altitudes, and it is thought probable that there is a law of large seed at low altitudes and small seed at high altitudes.

The points brought out may be stated as follows: The size of the seed is largely affected by the size of the cone, and is therefore greatest for the youngest trees. The size of the seed seems greatest, apart from the age of the tree, when the soil is deep and fertile, the climate is warm, and the stand is open. Only the effect of the age of the tree through the size of the cone is certain, but the other statements have good evidence supporting them. Conky trees have as large seed as sound trees.

The Yield of Clean Seed per Bushel of Cones

The yield of clean seed per bushel of cones depends upon the quantity and quality of the seed produced. The quality enters in because poor seed are blown away during the cleaning process. The quantity of filled or heavy seed is the yield after cleaning. This yield may be dependent upon growth or site conditions or it may be affected by a chance condition, viz., the extent to which insects have damaged the seed. Megastigmus larvæ were found in many seed, but the extent to which they were present, both before and after cleaning, varied greatly and could not be gaged in any particular case. There is therefore this "unknown quantity" which casts a little doubt over the following discussion.

The yield was investigated both according to weight and to number of seed per bushel of cones.

The age and size of the tree seemed to play no part in determining the yield of clean seed, either by weight or by number.

The latitude had no clear effect on either weight or number, while the altitude exerted a strong influence. Low altitudes gave both smaller

weight and smaller number of seed than high altitudes. Both latitude and altitude are thought practically ineffective, except as they may influence the prevalence of destructive insects. Thus the high yield from high altitudes is evidently the result of comparative freedom from insect attack high in the mountains, and this view is corroborated by an investigation of the seed, which showed that insect attack surely was worse at the lower elevations. The negative result of the latitude figures supports the view that not the climatic effect of altitude, but merely the chance condition of insect damage is involved, for latitude and altitude should be similar in their effects.

The quality of the soil the tree grows in, the openness or denseness of the stand, and the conkiness or soundness of the tree seem very important. All these affect the number of clean seed obtained and largely through this effect the weight of clean seed secured.

Trees growing on shallow, gravelly soil yielded but 9,500 seed per bushel of cones, as contrasted with 14,700 seed for trees on good soil.

The yield of forest-grown trees was 11,500 seed per bushel of cones, compared with 14,000 for open-grown trees.

Conky trees gave but 13,300 seed instead of the 21,500 seed which similar sound trees yielded per bushel of cones.

In other words, poor soil cut the yield down to 62 per cent of the normal, and conkiness of the tree reduced the output to 65 per cent of the normal. Lack of light (or close competition for moisture, etc.) also caused smaller yields. These points are among the most important brought out by the study.

Another interesting phase concerns the size of the cones. Large cones have more seed apiece, but there are fewer of them to the bushel. The pertinent inquiry is whether small cones or large cones are more economical to collect. It was found that the number of clean seed per bushel showed no relation to the size of the cones, and that it is immaterial from this standpoint whether large or small cones are gathered. The weight of cleaned seed per bushel of cones differed from the number, materially increasing as the size of the cones increased. Large cones yield large seed, and hence have a heavier weight of seed per bushel of cones, but they furnish no more seed than small cones.

To summarize the foregoing: The yield of clean seed per bushel of cones is poorest at low altitudes because destructive insects are here most prevalent. Poor soil or conkiness of the tree may reduce the yield to two-thirds of the normal. Forest-grown trees yield less than those open grown. The size of the cone is immaterial, so far as the number of seed per bushel is concerned, but since large cones have large seed they give a heavier weight of seed per bushel.

The Germination Per Cent

Taken alone, the germination per cent figures show little. They do not indicate the quality of the seed produced. They show the quality of the seed after cleaning; but cleaning theoretically brings all seed to a somewhat uniform grade of quality. Whatever differences there are in quality among various lots of seeds will usually show best not in germination per cent, but in—

1. The yield of clean seed (since the quantity of cleaned seed obtained depends on the quality as well as the quantity of seed produced).

2. The yield of good seed (which is the product of the yield of clean seed and the germination per cent).

Since it is the germination of the cleaned seed we are considering, the following statements should not be given too great weight; but it is nevertheless interesting to inquire how the per cents varied and to attempt to explain the differences.

The age of the tree had apparently no effect whatever on the germination per cent, and the variation in the amount of growing space the tree had was equally ineffective. There is great doubt whether health of the tree had any effect, but if it had its influence was negligible in amount.

Seed from trees growing on shallow, gravelly soil had a relatively low germination per cent; but this is at least partially explainable by the chance condition of more serious insect infestation in the localities which had poor soil.

Altitude seems to have an effect even apart from the question of relative damage from insects, which is greatest at low elevations. Below 1,500 feet elevation the per cent varied from 61 to 66, but fluctuated irregularly. These low figures and the fluctuations appear to result from insect attack. From 2,000 feet to 4,000 feet the per cent varied rather regularly from 74 at the former to 51 at the latter. This suggests a poorer quality of the seed at the highest elevations. The figures are considered good evidence, but not absolute proof of the supposition.

Latitude figures show that southern localities have a lower germination per cent than northern localities (63 per cent, as compared with 70 per cent). This difference is attributed to the greater damage from insects in warm regions.

The size of the cone plays no part in determining the germination per cent.

The figures for the size of the seed suggest the possibility of lower germination for the smallest seed, and perhaps even slight reduction in germination for the very largest of the seed. Except with seed extremely small the effect is not marked enough to be material. Even with those

running 55,000 to 60,000 per pound (the smallest seed found), there is reasonable doubt whether the size of the seed alone is responsible for the reduced germination.

To summarize: eliminating the results which are doubtful or perhaps caused by chance, altitude alone seems important in deciding the germination per cent. It appears that the quality of seed is poor near the upper limit of Douglas fir's range. The quality is poor at the lowest levels as well, but here insect damage is responsible.

The Yield of Good Seed per Bushel of Cones

This yield is determined mostly by the factors which decide the yield of clean seed per bushel of cones. This means simply that the cleaning process brought the various lots of seed so nearly to the same grade that the results of quality tests failed to contradict previous conclusions. The only exception is in the case of altitude.

The highest yield, according to altitude, is from elevations between 2,000 and 3,000 feet above sealevel. The yield here was 15,000 good seed per bushel of cones, as contrasted with 9,000 for the lowest levels and 12,000 for the highest. Insect depredations account for the low yield at low altitudes. The reduction in the yield for high altitudes seems the direct result of climatic conditions.

The other results corroborate previous conclusions brought out in connection with the yield of clean seed.

Shallow, gravelly soil resulted in a reduction of the yield to 54 per cent of the normal. Conkiness of the tree caused a similar reduction to 62 per cent of the normal. Trees in dense stands produced only 7,400 good seed per bushel of cones, as compared with 9,100 for trees open grown.

The yield of good seed per bushel of cones is therefore highest in open stands at moderate altitudes (2,000 to 3,000 feet). Conky trees and those growing on poor soil should be avoided in cone collecting, for they give relatively low yields of good seed per bushel of cones.

The Yield of Good Seed per Tree

The number of good seed per tree is the rather complex product of the yield of cones per tree and the number of good seed per bushel of cones.

The yield of good seed per tree is not affected by the quality of the soil, according to the figures obtained. This result is questioned, however. The trees on poor soil had much larger yields of cones than those on good soil, but this must be considered a chance condition caused by local variation in the cone crop. For the average of a term of years, poor soil should

certainly give no larger crops of cones than good soil. If this be admitted, then poor soil undoubtedly produces less good seed per tree than good soil, since the yield of good seed per bushel of cones is notably inferior on poor soil. If equal quantities of cones per tree are produced, poor soil gives only two-thirds as much good seed as good soil.

Conkiness of the tree has been seen to exert an influence similar to that of poor soil. The conky and sound trees had almost equal quantities of cones, and therefore showed big differences in yield of seed per tree because of the marked difference in yield per bushel of cones. This bears out the assumption that poor soil would normally give a low yield of seed per tree. Conky trees had but 7,700 seed per tree, while similar sound trees had 14,200, or nearly twice as many.

It seems fair to conclude that both poor soil and conkiness of the tree greatly reduce the yield of good seed per tree, though not the yield of cones per tree.

The age of the tree strongly influences the yield of cones per tree, but has no effect on the yield of good seed per bushel of cones; consequently the seed crop is highest at the age of highest cone production. Trees 100 to 200 years old bear most prolifically. The average 15-year-old tree had 4,000 good seed, the average tree 100 to 200 years old had 40,000, and the average 600 years old had but 7,000 good seed. This suggests the relative number of seed trees we need per acre according to their age. If very old or very young trees are left, there should be 5 to 10 times as many of them (*other things being equal*) as of medium-aged trees.

The density of the stand materially influences the yield of good seed per tree. The most reliable comparison shows 84,000 good seed on open-grown trees, as contrasted with 48,000 on forest-grown trees. The larger cone production on open-grown trees is the prime cause of the difference.

Altitude and latitude have marked effects upon the yield of good seed per tree. At the lowest elevations the production was 34,000 per tree, as compared with 4,000 for the highest elevations. Similarly with latitude: Southern localities had 35,000 seed per tree, while northern ones had but 7,000. These figures must not be taken literally, since they refer to the production of but one year, and chance local variations in the size of the crop may have been of vast importance. Nevertheless the tendency seems surely toward high yields in warm regions.

The points regarding the yield of good seed per tree may be summed up as follows: The age of the tree is of great importance, and much the largest yields come from trees 100 to 200 years old. Open-grown trees yield more than those forest grown. The production is relatively great in warm localities and comparatively small in cold ones. Poor soil and conkiness of the tree result in poor yields.

Application of Results

The following résumé will call to mind the facts brought out as to seed:

The size of the seed largely depends upon the size of the cone. For this reason the size varies inversely with the tree's age; young trees have the largest seed and old trees the smallest. Good soil, open stands, and warm localities seem to favor large size of seed. Conkiness of the tree does not cause the seed to be small.

The yield of clean seed per bushel of cones is small for low altitudes because of the abundance of destructive insects at low levels. Poor soil and conkiness of the tree seriously decrease the yield. Forest-grown trees yield less than those open grown. The size of the cone seems immaterial. Large cones yield a greater weight, but not a greater number of clean seed than small cones.

The germination per cent is reduced by extreme high altitude.

The yield of good seed per bushel of cones is the net result of the interplay of the factors which influence the yield of clean seed and the germination per cent. The yield of good seed per bushel of cones is reduced at low altitudes by insect attack and at high altitudes by climatic influences, and so is best at moderate elevations. Poor soil and conkiness of the tree greatly lessen the yield. Forest-grown trees yield less than those open grown.

The yield of good seed per tree is greatest at the age of 100 to 200 years. It is higher for open stands, warm localities, good soils, and sound trees than for the opposite conditions.

Application to Cone Collecting

In the discussion of cones it was remarked that the size of the cone has some weight in deciding which shall be collected, large cones being preferable, even though small ones are satisfactory. It was stated that young trees yield larger, though fewer, cones than middle-aged trees, and that these have the advantage in ease of climbing and picking. It was further remarked that warm localities have larger crops, but more insect infestation, so that localities with the largest crops are not necessarily the best to collect from. A crop large for the locality has the insect injury diffused, and a crop small for the locality is greatly damaged through the concentration of insect attack.

The size of the cone and its freedom from insect attack are good guides to quality, but they do not tell the whole story. Cones from dense stands, extremely high altitudes, shallow, gravelly soils, or from trees badly affected by conks give relatively low yields of good seed per bushel. So far

as is known, the appearance of the cones gives no clue to the quality in such cases, so that cones bought in bulk cannot be perfectly graded as to quality. When we collect our own cones we have the following rules to follow:

1. Collect large rather than small cones.
2. Avoid insect-infested cones.
3. Avoid cones from—
   a. Extremely high altitudes.
   b. Dense stands.
   c. Poor soils.
   d. Conky trees.

Rule 1 is not very important, but the observance of rules 2 and 3 will result in securing the maximum yield of good seed per bushel of cones.

It remains for the discussion of seedlings to show whether the quality of individual seeds varies greatly or whether the quantity of good seed secured alone decides where we shall collect cones.

Application to Timber-sale Seed Trees

The highest cone production is on trees of medium age, but rather large size, growing in open stands in warm localities. The production of good seed per tree is reduced by poor soil of the site and by conkiness of the tree, but is otherwise influenced by the same factors as the cone production.

Since young trees produce larger cones and seed than older ones, and have the further advantages of lower value and of greater freedom from windfall, it appears that they are very satisfactory as seed trees wherever they occur on timber-sale areas. A greater number of them will, of course, be left to compensate for the low yield per tree which results from the small size of their crowns. If it is necessary to leave very old trees, it should be remembered that more of them are required to secure the yield of seed of a given number of medium-aged trees. The high marketable value of the trees and the danger of windthrow, as well as the poorness of their seed production, argue against the leaving of very old trees wherever it is possible to avoid doing so.

Warm localities have such high yields per tree that it might be claimed that relatively few seed trees are necessary for them. It is doubtless true, however, that seedlings here become established less readily than on cooler sites, since hot sites are dry ones in our region. One consideration seems to balance the other, so no reduction in the number of seed trees in warm localities is considered warranted.

More seed trees than ordinarily would be left should be reserved if the soil is locally infertile or the trees are conky, for either poor soil or conkiness is apt to reduce the yield of good seed per tree one-third to one-half. This does not mean that the number of trees should be decided mathematically, for the spacing and height of the trees and various other matters enter in, and there is always the unknown quantity of the exact amount of seed necessary, considering the loss there will be in lack of germination and mortality among plants. The fact that conky trees and trees on poor soil are relatively poor producers should not, however, be lost sight of when seed trees are selected.

These remarks take note only of the quantity of good seed produced. Material variations in the seed will be discussed hereafter in connection with seedling data.

FACTS CONCERNING THE SEEDLINGS

Seedlings derived from the seed sown the spring following collection are now two years old and have yielded data as to height growth and rate of bud formation during the first and second years. Supplementing these figures are those for seedlings which were started the second spring following collection and which now are one year old. We have, therefore, the growth of two different seasons for one-year plants and the growth of the second year as well for one of the two series. Nevertheless, no finality is claimed for the conclusions hereafter given, for two years' observations are not enough to settle definitely all the questions involved. The behavior of the plants in the field after they have been outplanted on a variety of sites will eventually decide all doubtful points.

The influence of heredity on the rate of bud formation and the height growth of seedlings is hereafter discussed.

The Rate of Bud Formation in the Fall

It has long been recognized that plants inherit a tendency toward early or late maturing of growth, according as the parent trees had short or long growing seasons. It is of considerable practical value, especially in our planting work, to know how strong this tendency is and how prolonged is its effect.

The 1913 one-year-old seedlings showed clearly the influence of heredity on the rate of bud formation. On November 6 plants from seed collected below 500 feet elevation had only 38 per cent of their buds formed, as compared with 92 per cent for plants from seed collected at 3,500 to 4,000 feet. Latitude figures corroborated those for altitude. Thus plants descended from northern trees had 65 per cent of their buds mature, when only 20 per cent were formed on plants grown from southern seed.

In 1914 the figures for the one-year and the two-year seedlings showed no effect whatever of heredity on bud formation. All had over 95 per cent of the buds formed November 9, regardless of the altitude and latitude of their respective sources.

The difference between the 1913 and 1914 figures is doubtless attributable to the different character of the seasons. The summer of 1913 was wet, while that of 1914 was unusually dry. As nursery experiments have shown, dryness causes early maturing. The negative result of the 1914 figures probably means merely that exceptional conditions caused practically all seedlings to mature early, including the plants, which ordinarily would lag behind because of inherited tendencies to late formation of buds.

The conflicting data are interesting, as showing the opposing forces of heredity and environment. The rate of bud formation unquestionably is influenced by both and doubtless may be determined by either.

To be on the safe side it would surely be best to collect seed from places colder than the planting site, so that the inherited tendency would be toward relatively speedy maturing of growth. If the parents had growing seasons shorter than that of the planting site, the seedlings would be apt to mature early and to escape frost injury. No stronger statement than this can be made until future observations show more definitely the strength and persistence of the inherited tendency.

The Rate of Growth

The height growth of the two-year seedlings was measured November 6, 1913, and November 9, 1914. At the latter date two measurements—the growth during 1914 and the total height at the end of 1914—were taken. The growth during the second season is much more reliable than the total height, because a late frost in April, 1914, killed much of the early growth of this year and killed it variably and erratically in different lots of seedlings. The total height of two-year seedlings will therefore be disregarded hereafter. The growth during 1914 is more trustworthy, for it is taken from either the uninjured terminal shoot or from the lateral shoot which obtained the lead. For the one-year seedlings we have the growth during 1914, and these figures are lower than those for the 1913 growth, at least, partly because of the greater severity of the 1914 season.

Brief summaries of the data obtained will be given for each phase of the following discussion and the net results of the different influences will thereafter be taken up.

The Effect of the Age of the Parent Tree

Age of tree, years.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
14 to 78	1.5	2.2	2.7
100 to 250	1.5	2.0	2.4
310 to 600	1.4	1.8	2.9

The age of the tree, doubtless through the size of the seed, had a marked effect on the height of one-year seedlings in 1913 and a slight effect in 1914. The 1913 figures are doubtless more reliable as showing the normal result. Conflicting factors in 1914 obscured, but still did not offset, the effect of the age of the tree. In the second year the effect seems negligible, so the age of the parent is seemingly of slight importance in the long run.

The Effect of the Growing Space the Parent Tree Has

Stand.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
Open	1.5	2.2	3.0
Dense	1.5	2.1	2.8

It seems that the height growth of the seedling is slightly affected by the growing space the parent tree had, and that the influence is carried beyond the second year. Future observations will determine whether the differences are of real importance.

The Effect of Conkiness of the Parent Tree

Class of trees.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
Sound	1.6	2.0	2.8
Conky	1.4	1.7	2.3

Conkiness of the parent tree appears to cause a consistent reduction in the seedling's growth, both in the first and second years. Whether the effect is of material importance must be left for future observations to decide.

The Effect of Poor Soil of the Parent Tree's Site.

Soil.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
Shallow, gravelly	1.7	2.2	2.4
Good sandy loam	1.5	2.2	2.8

The figures indicate no effect whatever on the first year's growth, but suggest an effect in the second year. Future observations must corroborate the latter before great reliance can be placed in the data.

The Effect of the Latitude of the Site of the Parent Tree

Localities.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
Southern	1.6	2.3	2.7
Northern	1.6	1.9	3.0

The figures show conflicting results for the first and second years and indicate no real effect of latitude. The range of latitude, however, was relatively small in the study, so the results are not necessarily applicable to great differences of latitude.

The Effect of the Altitude at which Parent Tree Grew

Elevation, feet.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
Under 1,000	1.6	2.2	2.8
1,000 to 2,000	1.4	1.9	2.6
2,000 to 3,000	1.3	1.7	2.3
3,000 to 4,000	1.2	1.7	2.0

The altitude from which the seed came exerts a clear influence on the growth of both the first and second years. It remains to be seen whether the differences are material and permanent or unimportant and transitory.

The Effect of the Size of the Seed

The average figures for seedling growth from different sizes of seed follow. It will be remembered that the largest seed are those which have the smallest number per pound.

Seed per pound.	Height growth of seedlings per year, inches. Seed sown, 1914. Growth, 1914.	Seed sown, 1913. Growth, 1913.	Seed sown, 1913. Growth, 1914.
30,000 to 35,000	1.7	2.4	3.4
35,000 to 40,000	1.5	2.1	2.5
40,000 to 45,000	1.5	2.0	2.5
45,000 to 50,000	1.5	1.9	2.9
50,000 to 55,000	1.5	1.6	2.9

The 1913 figures show clearly that large seeds yield large one-year seedlings under normal conditions. The 1914 figures do not bear this out very well, doubtless because external conditions here tended to make

all seedlings stunted. The effect of the size of the seed seems largely lost in the second year.

Other Influences

At the end of 1913 it was apparent that the height of one-year plants was closely related to the time of bud maturity. Where less than 10 per cent of the buds were formed November 6, the plant was 2.3 inches tall, as contrasted with 1.8 inches where over 90 per cent of the buds were formed before this time. It was thought that the relation was very simple, and that the largest plants grew large merely because they had more time to grow in, on account of the late maturity of their buds. In 1914, however, the differences in the time of bud formation were exceedingly slight, and yet the growth was affected by the altitude from which the seed came, showing an apparent inherent tendency toward fast or slow growth independent of the time of bud formation.

A law worked out by German foresters shows that small, weak plants are obtained where the seed, being poor, has a low germination per cent. This was corroborated in 1913, where the averages were 1.6 inches height for germination under 20 per cent, 2.0 inches height for germination between 21 per cent and 60 per cent, and 2.1 inches height for higher germination. One lot of seed had a germination of only 2 per cent, and the plants from it were but 1.1 inches tall. The 1914 one-year-old seedlings showed a similar relation of height growth to germination per cent. The effect, however, was wholly lost in the second year, according to the figures obtained for the second year's growth of the 1913 seedlings.

Environment

The effect of heredity has been taken up, but the discussion of height growth is incomplete without further reference to environment and its influences. There is a comparison concerning environment afforded by the sowing of the same seed in two different years. Any differences between the resulting seedlings are likely due to environment, not heredity; to differences in the temperature, precipitation, etc., of the two growing seasons. There is, however, the chance that the drying to which the seed was subject in the year it was held in storage had a prominent part in reducing its quality, and therefore the height growth of the seedlings derived from it. However this may be, it is certain that external conditions (storage of seed or environment of seedlings) had far greater effects than heredity on the height growth of one-year seedlings. This can readily be seen by glancing back over the figures above given.

Age of the parent tree may be cited as an example. The "normal" may be taken as 2.2 inches height, the figure for the youngest trees in the 1913 series. Heredity in an extreme case cut the height down to 82 per cent of the normal. External factors reduced it to 68 per cent of the normal.

Excluding the figures for "size of seed," which really do not apply to heredity, all the figures show that external conditions have greater influence than inherited tendencies. It would be premature to draw far-reaching conclusions from this, however, for inherited tendencies may be found to have vast and long-continued influences, even though they may be obscured in certain years by external conditions. As suggested in the discussion of bud formation, it is well to keep on the safe side at present by giving full weight to the facts brought out as to heredity until such time as we can definitely conclude that adaptation to environment will or will not wholly offset heredity.

Summary of the Inherited Characteristics of Growth.

If only the 1913 results were available, we would be justified in summarizing the conclusions as follows:

Height growth the first year is greatest when—

1. Seed is largest.
   Seed is largest, so plants largest, if—
   - *a.* Parent was young.
   - *b.* Parent had abundant growing space.
   - *c.* Parent grew in southern region.
2. Seed has high germination per cent.
3. Buds form late in season.
   Buds form latest, so growing season longest and plants largest, if—
   - *a.* Parent grew in southern region.
   - *b.* Parent grew at low altitude.
4. Vigor is obscurely inherited.
   Thus seedling is largest if—
   - *a.* Parent was healthy (not conky).

The 1914 figures for one-year seedlings taken alone would not have permitted these clear-cut conclusions, for the effects of heredity here were obscured by other influences. Nevertheless they support the conclusions instead of opposing them.

The two-year seedlings seemed to show that size of seed, germination per cent, and time of bud formation soon lose most of their influence.

Conclusions regarding the second year's growth are summarized below. These conclusions likewise apply to the sum of the first and the second year's growth (though not to the total height at the end of the second year, which was rendered erratic by frost injury).

Height growth the second year is greatest when—

1. Vigor is obscurely inherited.

    Thus the seedling is largest if—

    a. Parent had abundant growing space.
    b. Parent was healthy (not conky).
    c. Parent grew at low altitude.
    d. Parent grew in good soil.

Application of Results

In the following pages all the important facts brought out by the Douglas-fir seed study are summarized.

Application to Cone Collecting

In the discussion of the seed it was stated that large cones are preferable to small ones, though the latter are satisfactory. The largest cones yielded the largest second-year plants, though smaller cones did yield especially small seedlings. The general rule of collecting the largest cones is probably worth following, though not of great importance.

The figures for time of bud formation indicate that plants may change their inherited growing seasons under the influence of external conditions. Nevertheless it seems best to gather cones from regions or altitudes at least as cold as the planting site, for danger of frost injury is apt to be less if the inherited growing season is shorter than that of the planting site.

It is of special interest to note that the factors of poor soil, small growing space, and poor health of tree, which result in small yields of good seed per bushel of cones, also cause poor height growth of plants.

All things considered concerning cones, seeds, and seedlings, the following rules for cone collecting are suggested:

1. *Gather cones in a locality as cold as or colder than the planting site.* The likelihood of frost injury to seedlings is doubtless less if the parent formed buds before the date the seedlings are exposed to frost, and the colder the locality of the parent the stronger is the tendency toward early maturing of growth.

2. *Avoid extremely high altitudes in collecting,* unless the planting site is very high. Usually high elevations give relatively small yields of good seed per bushel of cones.

3. *Avoid insect-infested cones,* on account of the small amount of good seed they yield. Insects are worse if the crop is small for the locality, for their attacks are then concentrated. Comparing localities in a given year rather than years in a locality, they are worse in the warmer places where the crop is normally large. Crops large for the particular locality, but small in comparison with other localities, are apt to be least infested.

4. *Do not collect from sites with shallow, gravelly, or otherwise poor soil.* Such sites give a low production of seed per bushel of cones. They seem also to cause an inherited stuntedness of seedling growth.

5. *Collect from young or old, small or large trees, as convenience demands.* Small, young trees give large seed, and thus a relatively great weight, with no unusual number of seed per bushel of cones. Seedlings from young trees are relatively large the first year, but not especially so the second year.

6. *Seek large cones.* This is not a very important rule, but should be followed where practicable. Large first-year seedlings come from the large seed of large cones, but the advantage of size is apt to be largely lost in the second year.

7. *Collect from open-grown trees* where practicable, since such trees produce larger crops of cones, larger yields of good seed per bushel of cones, and larger two-year-old seedlings than do forest-grown trees.

8. *Avoid trees infected with fungous diseases, "conky trees,"* for these have poor yields of good seed per bushel of cones and give rise to rather stunted seedlings.

Application to Timber-sale Seed Trees

The results of the study, so far as they apply to seed trees, may be summed up as follows:

The highest cone production is on trees of medium age, but rather large size, growing in the open in warm localities. The production of good seed is reduced by poor soil of the site and by conkiness of the tree, but is otherwise influenced by the same factors as the cone production. The height growth of the seedlings is better if the parent tree grew in an open rather than a dense stand. Poor soil of the site and conkiness of the parent result in rather small second-year seedlings.

The suggestions in regard to seed trees are:

1. *Leave old or young, large or small trees, as seems best from the consideration of marketable value of trees and danger of windthrow.* The seed production of very young and very old trees is only about one-fifth the production of middle-aged trees, so a greater number should be left per acre if extremely young or old trees are chosen. Apart from the

size of the seed crop, there seems no material point in regard to the age of the tree.

2. *Open-grown trees, which are usually preferred for seed trees, are surely the best ones to leave* if they occur on the area. These give more seed and better seedlings than other trees and are likewise more windfirm.

3. *If practicable, avoid conky trees,* since they produce relatively small seedlings. Conky trees produce less seed than sound ones, so more trees per acre are necessary if the ones left are badly affected by fungous diseases.

4. *Avoid if practicable as seed trees those which grow on local patches of inferior soil,* for these give smaller amounts of seed and smaller second-year seedlings than trees on good soil.

It has not been proven that conky trees and trees on locally poor soil should never be left as seed trees, but it seems best to avoid them where practicable. The future must decide whether the inherited stuntedness of the resulting seedlings is but a transient and slight effect or whether we actually lower the quality of the forest by leaving poor seed trees. This is one of the most interesting questions involved in the future of the study.

THE BEGINNINGS IN THE DEVELOPMENT OF A PRIVATE FOREST ESTATE IN NEW ENGLAND

BY GEORGE H. MEYERS

Contributed

It is a fixed principle that forestry can be practiced to better advantage on lands owned by the public or by corporations rather than on lands belonging to individuals, whether these individuals be operating investors in timber lands or others whose ownership cannot carry a permanent policy of management beyond a single lifetime. But private forestry is entirely practicable on tracts of two or three thousand acres or more, where there is a family tradition conducive to permanent ownership, where additional returns can be credited by the owner to his pleasure, health, or desired landscape effect, or to the improvement of shooting, hunting and fishing, and other special uses.

Circumstances of this kind constitute a phase of forestry perhaps more common in the United States than elsewhere. It is characterized by private ownership of tracts which are mostly forest land, or suitable only to be under forest, but where forest management has never been practiced and where the conditions dictate a form of management according to the principles of forestry; but where other factors also must be considered, such as those above mentioned.

There is probably no other country where there is so much land of this kind available for private purchase and so many individuals financially able to hold it. The financial returns, however, from such tracts cannot be accurately estimated on account of the length of time required to get the tract under complete forest management, and because other uses for the land dovetail into its use for the growing of timber. For example, it may be necessary to build certain roads of better grade than forest management would require; labor must be used for outside purposes, and superintendence can seldom be charged entirely to forest management.

A tract of this kind is herein described. Part of it was bought with forestry in view; other parts for other reasons. I own it and use it as a home during part of the year, and the other uses above mentioned are all considered.

In 1906 I purchased about twelve hundred acres of land in northeastern

Connecticut. My reason for doing so was because the cost of land was so low I thought that at the worst I could lose very little. My intentions regarding it were vague, but, in general, my idea was to prevent fire and plant all waste land with white pine. Since that time I have continued to buy land adjoining or near this first purchase, in order to solidify my holdings and to obtain more land already having volunteer stands of young white pine upon it. Next in availability for purchase to land already stocked with young white pine I considered land suitable for planting and land already having timber upon it, which could be cut in the near future at a net return which would practically cover the purchase price. The initial capital investment was small; taxes are sure to be low for a period of years, and the principal charges against the land are therefore those for physical improvements and silvicultural operations.

In assembling a comparatively large tract of land in this locality, it is, of course, necessary to buy a considerable area which does not fall into any of the above classes. The present tract therefore consists of an area of 5,000 acres, which included approximately 150 acres of land recently under cultivation and several hundred acres covered with brush and broken stands of woodland. Taking the area as a whole, it is typical of southern New England, a distance of ten miles or more from the railroad. The farms have gradually decreased in size with a local decrease in the population, and the forest land has proportionately increased.

The elevation of the tract is from 700 to 1,100 feet above sea-level.

The topography consists of a series of ridges, the general trend of which is southwest and northeast. The valleys between them are narrow. Some of the bottom-lands are swampy, and some are sandy and too leachy in character for cultivation. The soil is a sandy loam, with considerable surface rock and ledges. The best land is on the lower slopes and benches.

The numerous old wood roads have been cleared and are used for both transportation and fire lines. The swamps are available as fire lines and some have been converted into ponds. The overgrown pastures are the least desirable, because they are expensive to bring under forest; nor are they of much value for pasturage, because they occur in small areas which are too expensive to fence for the small amount of open grazing land available. In general, the whole area is unusually well adapted to the rapid growth of white pine.

The facility with which natural reproduction of white pine takes place has served to maintain this species over the whole area, either in nearly pure stands or in mixture with hemlock and hardwood. This condition has been maintained in spite of the fact that cutting has included all

white pine except the poorest and smallest, while only the best hardwoods and hemlocks have been taken.

When the tract reached a size which permitted placing it under economic forest management, as an independent unit, I realized that I must change my policy regarding it. It was evident that for this purpose I must have labor available on the spot. This necessitated some cultivation of the small farms in order to supply the needs of resident labor and animals. I discontinued forest planting on tillable land, repaired all houses which were not too far gone, and looked forward to maintaining the present area of tillable land and open pasture.

The operations now being carried on consist of:

1. Surveying.
2. Fire prevention.
3. Road and trail construction.
4. Planting.
5. Liberation cutting; also known as "disengagement cutting." For this operation I use the word "freeing," which I prefer on the score of brevity.
6. Thinning.
7. Construction of dams.

These will be taken up in the above order.

1. *Surveying.*—Surveying for the purpose of mapping the tract has been done piecemeal. Mapping was necessary in order to establish boundaries as fast as separate lots were purchased. Many corners were in doubt, some in dispute, and it is impossible to foresee which of these will become "interior bounds" after additional purchases of land. This work has been left for winter and rainy days, when other work is least pressing. The purpose is eventually to complete the map of the whole tract on a scale of twenty rods to the inch. Geological Survey maps are available for the topography, although in this locality they are not entirely accurate. The map, when completed, will show location of roads and trails, houses and farm land, permanent water, fire lookouts, and perhaps forest types.

All these are sufficiently simple except the matter of forest-type mapping. On this matter nothing has as yet been done on paper. Up to the present time the forest-type map exists only in the form of familiarity with the tract in detail in the minds of the owner and superintendent. It is a great question in my mind whether such a map can be made to pay its cost if a proper charge is made against it for the labor of making. Certainly a forest-type map demands the time of a high-salaried man.

If this man is permanently on the work, he does not need the map. If an expert is employed for the purpose, a great part of the value of his time is lost when he leaves, because in stands which vary as they do in this locality the best of the data for making a type map cannot be satisfactorily put on paper for the use of others.[1]

2. *Fire prevention.*—Fire prevention on the tract consists of the following operations:

First. Location of natural and artificial fire lines.

Second. Construction of roads and trails. (This is dealt with under transportation, though it constitutes the more important part of fire prevention as well.)

The location of natural and artificial fire lines has reference to the following:

(*a*) Wood roads already existing.

(*b*) Standing and running water.

Standing water is conserved and deepened at strategic points where it does not injure valuable tree growth. Permanent water in springs and small swamps is located during the periods of drouth, and holes are dug at points accessible to roads to save as much water as possible. These holes are from 2 to 4 feet deep and from 3 to 6 feet in diameter. These water-holes are supplied with trails to the nearest road, where a sign reading "water" is placed, together with a pail and mop consisting of a stout stick cut on the spot with a "bran-sack" tied to one end. It may be worth noting that a good water-hole can generally be found at each "old setting" or former portable mill location. Of these there were 33 on the first purchase of 1,200 acres. Mills were generally placed where permanent water could be gotten by digging close beside the boiler. Clearing out these old holes is much cheaper than digging new ones.

(*c*) Old stone walls which can be joined with other fire lines are located and cleared of tree trunks and branches.

(*d*) Lookout points are cleared on exposed ledges on the ridges. Lookout towers are to be built on high hills where tree growth makes it necessary.[2] The purpose is to connect these lookouts, so far as economy permits, with telephones to various houses on the tract.

(*e*) Finally, a telephone line will be completed from northwest to southeast, the longest diameter of the tract.

3. *Road and trail construction.*—Roads and trails of three classes are being built:

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[1] I should be glad to hear a discussion of this subject, and am well aware that the above view is heretical.

[2] In the matter of timber *versus* steel as material for these towers and the best and cheapest construction, I would be glad to get some information.

First. Main roads, passable for motor-cars. At present such roads are built about 12 feet wide, with a rod of cleared ground on the two sides together. The width of both roads and clearings in all classes should be greater and will be increased later on.

Second. Roads passable for horse-drawn vehicles. This class is at present even less in width than the first, and is made chiefly by clearing up the lumber roads and wood roads of former cuttings, improved by the removal of the worst stumps, rocks, and grades.

Third. Trails to serve as short cuts and minor fire lines. These are cut for short distances, but generally the remains of old roads are available. They are for foot travel and horsemen.

The maximum cost of these three classes is at present approximately $1,000, $100, and $25 per mile respectively.

4. *Planting.*—Planting is practically confined to white pine and will not be necessary on more than 5 per cent of the area. White-pine planting may be divided into four classes:

First. On "mow-land." This is confined to small, inaccessible fields. Seedling stock is of little value in competition with grass, and my practice is to use three-year-old transplants, planted in furrows plowed 6 feet apart. The trees are spaced 6 feet each way. All sod should be left as turned by the plow and none of it replaced around plants.

Second. Planting on "cut-over land." For this purpose two-year-old seedling stock can be used, unless the open ground is covered with grass or unless a sufficient period has elapsed after cutting to allow other growth to take possession of the ground. My practice is not to attempt to maintain either rows or six-foot spacing, but to make use of all open spaces in the soil cover. The hardwoods thus take the place of that part of the planted stock which would be suppressed or killed during the first 10 or 20 years. These plantations will, therefore, result in a mixed stand, in which from time to time the pine will be aided by "freeing."

Third. Planting on burns. Fortunately I have not been obliged to do much of this kind of planting; but my practice is to use two-year-old seedlings and to sacrifice regularity of rows in order to utilize the best individual spots for the stock.

Fourth. Planting in pastures. Very little such planting has been done because there is little superfluous grazing land, and overgrown pasture is expensive to clear sufficiently to obtain an even-aged stand.

In general, my practice in planting pine is to use whatever growth is already started in order to complete the soil cover as soon as possible. White pines are therefore planted with a view to their all forming a part of the merchantable stand, and the maximum number used per acre is

about 1,000, except on "mow-land," where six by six spacing is maintained. Perhaps the more important parts of the white-pine plantations are those consisting of one, two, or three hundred plants per acre, used to fill small blanks in the cover. A thousand plants used in such planting are worth much more than if all are planted on a single area of less than one acre.

To recapitulate, transplants are necessary for grass-sod lands. Transplants are optional for brush lands. Good seedling stock has the advantage of economy in greatly reducing the initial investment in stock and labor and should be used on freshly cut-over land and recent burns. The number used per acre varies from 100 to 1,000 and is inversely proportional to the amount of existing soil cover.

5. *Freeing.*—Freeing appears to be the most important of any single silvicultural operation on this tract. A very large percentage of the total area is more or less stocked with volunteer growth of white pine. The exact percentage of the area thus covered could not be obtained except by using a definite minimum unit of area and an exact percentage of full stocking. Even using the smallest practicable units, many small areas large in the aggregate would be excluded. (See discussion of forest-type mapping.) Reproduction of this character is not so subject to attacks of weevil as plantations of pure pine. A partial stocking of white pine in mixture with various hardwood species is probably of as much value as a full stocking of pure white pine. On all this area the chief object in view is to aid the white pine, so as to maintain a sufficient representation in the mixture to form practically the whole of the final stand on a rotation of 50 years or more. Until the stand reaches an age of 15 years and a height of 15 to 20 feet, this is accomplished by the operation of "freeing." The chief difficulties are to get an efficient crew for the purpose. I have found that it is best to employ young men, because it is easier to explain to them than to older men the object and to get them interested in the work. Young men are also less likely to object to working in the thick cover and slash, where most of the work has to be done. The crew consists of either three or four men placed in a line one to two rods apart. The best two men should be at the ends of the line and should do their cutting so that it will show the area covered. This is accomplished by turning the tops of young hardwoods which are cut off, so that the under sides of the leaves will be turned upward. These are quite conspicuous and easily seen. Occasional trees are blazed on the outside of the line. They proceed in a line, as nearly straight as possible, until a strip has been taken through the area to be covered. They then turn back on a parallel strip, so that the outside man follows his own

line on the return trip. Number three or four, as the case may be, thus becomes number one, and number one takes the outside of the line, which he, in turn, will follow back on the third strip.

In the case of a green crew, it is better for three men to form the line, while the best man in the crew follows slightly behind to watch the work of the other three to free trees which have been neglected by the rest of the crew and to aid number three in keeping his line. The second best man of the crew should take position number one. The men must be taught that careful work is most important where the pine forms a small percentage of the stand, and also to avoid cutting valuable species like white ash and the best oaks, wherever these individuals show more promise of forming a part of the final stand than the white pine, to which they must otherwise be sacrificed. They must also be taught that it does not pay to expend much labor on trees which are already too nearly suppressed, and that where pines are abundant it is not necessary to free overtopped plants which have better-situated pines close to them. They should remove pine leaders affected by weevil and also superfluous leaders, where there is more than one, and lateral branches which are liable to form extra leaders.

Freeing is best accomplished when the hardwoods are in leaf, except in cases where the pine is already so covered that it cannot readily be seen under the hardwoods. In such growth the work should be done in the early fall or in the spring after the leaves have started. If the work is done in the winter, the hardwoods which it is desired to suppress are less successfully retarded in growth, and it is more difficult for the average laborer to see hardwood branches which are whipping the pines or which will shade them when in leaf.

To recapitulate, freeing should begin when the pine leaders begin to be whipped or shaded by the hardwoods. The crew should consist of the best young men available and should do most of their work in the moderately stocked area. The tendency of the average hand is to spend too much time in overstocked areas and on hopelessly suppressed trees.

A rough estimate of the cost of freeing is \$1 per acre. Where labor costs \$1.75 per day, this allows one-half day's labor per acre, with a small allowance for time consumed en route to the work.

6. *Thinning.*—Thinning is an operation which, unfortunately, can seldom be carried out along purely silvicultural lines. Labor spent in thinning is often wasted, owing to conditions which develop at a later period; thus thinning recently made in favor of chestnut has been spoiled by the chestnut blight. White oak, which might naturally be favored, may have to be removed, so far as possible, to retard the gypsy and

brown-tail moths. Thinnings are confined, on account of the high cost, to trees which will at least pay the cost of removal. The exception to this rule is the removal of large hardwoods in white-pine stands. Surprising increase in growth, even in stands of large pine, can be brought about by the removal of a small number of large hardwoods. The removal of "wolf" pines may also be included in this category. The variability of pine stands not previously under management makes it necessary to treat almost every fraction of an acre differently. In general, the length of time elapsing between thinnings and the severity of a given thinning must be in inverse ratio to the age, size, and crowded condition of the stand.

7. *Construction of dams.*—Dams have been constructed for a triple purpose. There was once a considerable number of dams which supplied water-power for small sawmills, shingle-mills, grist-mills, and similar uses. Some of these were worth repairing, but in most cases new dams of better construction had to be built in order to make ponds to supply water-power for fishing and boating, to stop fires or furnish water for fighting them, and finally for future transportation of logs, either in the water or on the ice. This last purpose will eventually be of considerable importance, because a long, narrow pond, with a water-mill at its lower end, will make it possible to use economically the product of a thinning which could not otherwise be handled. For example, a thinning on ten acres of pine, a quarter of a mile from the upper end of such a pond, might produce from 25,000 to 50,000 feet of lumber. This would not be sufficient to pay for setting up a portable mill, but it might be cheaply hauled down to the pond and floated or hauled over the ice to a water-mill, a mile distant, where it could be cheaply sawed and "stuck out" close to a main road.

Volunteer stands of white pine seldom, if ever, are uniform over areas of more than ten acres; but they do occur on this tract in many smaller areas, the total acreage of which represents a considerable percentage of the whole tract.

Such ponds and water-mills as those here described may make merchantable the products of thinnings on these small areas of pine which could not be economically handled if it were necessary to set up a portable mill for the purpose. The improvement in the amount and quality of the stand remaining after such a thinning might therefore be credited to the pond and water-mill.

On the other hand, a portable mill is necessary for use on parts of the tract which are not accessible to any of these ponds and water-mills. If the portable mill cannot be kept in use on such locations, then the in-

terest of the capital invested in the portable mill must increase the cost per thousand feet in its operation.

The cost of these ponds and water-mills is also an important item and forms a typical example of the difficulty of properly estimating costs which should be charged to forest management on such tracts as the one under discussion. The ponds which furnish possible locations for water-mills are built, as elsewhere stated, for a different number of purposes. It is therefore questionable what part of the cost of the dam and flume should be charged pro rata to the cost of sawing.

Also the installation of a small permanent plant does away with the cost of frequent moving of machinery and boiler, if the portable is used, and lessens the depreciation due to wear and tear, as well as the chance of fire damage, which accompanies the use of a portable mill in any season except winter.

The whole matter of water-mills *versus* portable mills brings up the question of the normal equipment for converting the products of such tracts.

It has always seemed to me that the existence of plants with artificial power in the woods depends upon an accumulation of wood products for a period longer than the rotation which would be used under forest management, except in the case of exclusive use of the clear-cutting system.

If a crop, such as corn or wheat, can be imagined to accumulate for a number of years, it is probable that the machinery for harvesting would be different from that actually used now. This difference would be increased if we imagine a field crop which should be thinned a number of times during its growth. Up to the present time a great part of the white pine in the Northeast, and the hardwoods as well, have been marketed by owners who made the purchase with the idea of cutting off all the merchantable timber and then abandoning the land or selling it as soon as possible for a very small amount.

These owners are the operators of portable mills who invest any proceeds of their land sales and cutting operations in other tracts of merchantable timber, to which they move their portable mills, together with a more or less permanent organization of crews for mill, woods, and transportation. Such conditions seem entirely different from those which will obtain when a large proportion of our white-pine lands are under forest management in the hands of permanent owners.

It is true that this contrast is of less importance if it should develop that the clear-cutting system is the only proper one for handling white pine and its associated species in this region. I do not believe that this will be the case.

It may be proper to go further and consider in this connection what proportion of the profits accruing to operators, like those described above, depend upon the purchase of merchantable timber at prices far below their true stumpage value. It is undoubtedly true that comparatively low prices for finished wood products have obtained in this country. There has been closer competition in the price of the finished products. On the other hand, true stumpage values have not been generally known. With the increase in the adoption of forest management and with the progress of forest engineering, true stumpage values will become better known, more stable, and doubtless considerably higher than at present.

My theory that small plants using natural powers in the woods will take the place of portable mills and large manufacturing plants is borne out by the fact that in countries where forest management has been practiced for a considerable time, more use is made of the small natural powers and the portable mills are less used.

Conversely, the largest wood-working plants are found in such regions as the Pacific coast, where the accumulation of wood in very old stands shows the greatest contrast to the merchantable stands of the South, with the shorter rotations which must be adopted under forest management.

I have wandered somewhat from the discussion of the Connecticut tract, but it seems to me that the method of forest management in the Northeast depends upon the correctness of the theory which I have explained.

GAME ON THE NATIONAL FORESTS

BY SMITH RILEY

Delivered before the Society January 27, 1915

What should be the Federal government's policy governing the protection and development of game in the National Forests? This question has been asked many times of late. A governor of a western State that still contains a large amount of big game expressed the doubt, soon after taking office, and asking whether it was true that elk shed their antlers each year, as to whether it was not advisable to have open season the year round on all big game and put domestic stock upon the ranges the game now occupies. Many people point out that the average big game State in which National Forests are located does little to enforce or improve its game laws, and therefore the people really do not care what becomes of the game. This is clearly shown, it is argued, by the rapid disappearance of game from those regions where a short time ago it was plentiful. Then it is right and just that the game or wild life should disappear as the lands become settled, because settlements and wild life do not go together. As the doubt grew up in that governor's mind, the game is hard to protect, and besides the sheep and cattle men need the range.

So truly do a large number of western people feel that all the game will go that they look upon the enforcement of effective game laws as a needless expense to the State. It is pointed out that the American principle of State game protection as a public property has failed in older and more thickly populated countries of Europe, where game culture is confined largely to privately owned lands, and the laws are now framed to protect game developed in this way. Well, the fact remains, there are large bodies of National Forests throughout this country where the remnant of game animals still remaining now exists and the problem is before us as to what attitude the Federal government is going to take in the matter. Of course, it must not be forgotten that the courts have repeatedly held that the game is the property of the States, and these forests are located in States that for the most part have good game laws and a force of game wardens to enforce these laws. So why should the Federal government do anything?

Owing to the obligations that the Federal government assumes in the

establishment and the maintenance of these National Forests, it must outline and operate under a definite, clear-cut game policy.

There is hardly a township of the 180 millions of acres of National Forest lands but what one-fifth to one-third is suitable only for game range. I mean by this that of this vast acreage at least one-fifth to one-third cannot now, and can never, be used by domestic stock. This, of course, does not take into consideration the large areas now inaccessible that will eventually be used for stock grazing. To my mind, the fact that deer were fairly plentiful in the Uintah Forest of Utah during those years when the ranges were so heavily stocked with sheep that the animals came off the range in the fall poor, the existence of elk on the South Fork of Rio Grande in the Rio Grande Forest of Colorado in the very heart of a range section that the cattle and sheep men fought over before the forest was created, is ample proof there is room for the game as well as the domestic stock. It has been gravely pointed out that the Federal government should go slow in this matter, because it would never do to adopt a policy detrimental to the stockman's interests. There are in every community a thousand and one champions for domestic stock, so we can rest assured that the sheep and the cow and the horse will be placed upon every acre where any one of them will thrive; in fact, the people of the West are commencing to believe that they may see both sheep and cattle upon the same area in spite of the many bitter struggles of the past that would tend to show this impossible. If game is to hold its own against domestic stock, it must have the biggest champion to be had—the Federal government.

The line to be drawn between the game and domestic stock is not hard to define. The sentimental side of the question can be eliminated, as far as the National Forests are concerned, and we should look at the matter entirely from a practical dollar-and-cents basis. In other words, here is an area not now grazed by stock. It will be a matter of 8 or 12 years before it will come into use, if at all. Why not have game here until domestic stock needs the range? Here is an area where more than 50 per cent of the land is so rough and broken as to be unfit for domestic stock, and the remaining 50 per cent is so located that the available stock will have to be driven long distances to the areas; so far, in fact, that all the profit will be lost in this drive. Why not have game here? Here is a region surrounding an area intensely used for recreation as a summer resort, or it is the watershed of some stream from which a town or village derives its water supply. It is not advisable to graze stock on such lands—first, because the people protest against it; and, second, there is a chance of stream pollution. Why not have game here? Here is an

area where there is a very small per cent not suited to domestic stock and yet suited to game; also a portion of the stock range must act as winter range for the game developed upon the smaller area. Would it not be advisable to protect and cultivate game upon the smaller areas and so allot your stock upon the larger area to provide winter feed for the game, and thereby get a more complete use of all of the land? In most cases that amount of growth necessary to leave to perpetuate your forage values would furnish winter feed for the game. Here again is a range where there is a large amount of forage and browse growth, and even when the areas are fully stocked with cattle or sheep, or even sheep and cattle, there are both forage plants and browse brush that the domestic stock do not eat, and game animals will eat these plants and thrive among your domestic stock. Why not protect the game and cultivate it here?

The question is asked, Will it pay to protect and develop game in the National Forests? My answer to this is that it will pay and pay in big interest on the time and money put into it. There is not a State today that has put money into game protection but has received big interest on the investment. It will pay on a dollar-and-cents basis just as big returns as any stock business, and the value of such game protection to the citizens of the State and Nation will be beyond a money value. What man among you has not felt, after a long grind at any kind of work, the keen pleasure of preparing for a trip in the open? It matters not whether you are a hunter. The wild life is a part of the open and its presence there will add many fold to its attractiveness. With what keen joy does the individual, returning to his work from such a trip in the open, tell of the game he has bagged, the wild life he has taken pictures of or just observed!

Dr. Hornaday has said: "The great value of the game birds of America lies not in their meat pounds as they lie upon the table, but in the temptation they annually put before millions of field-weary farmers and desk-weary clerks and merchants to get into their beloved hunting togs, stalk out into the lap of nature, and say, 'Begone, dull care!' And a man who has had a day in the painted woods, on the bright waters of a duck-haunted bay, or in the golden stubble of September, can fill his day and his soul with six good birds just as well as he can with sixty."

And so it is with the game animals. This last summer I was with a party for several days in the mountains of Colorado, just above Grand Lake. The real excitement of the trip, that caused the greatest thought and the biggest topic of conversation, was the day we came around a point of rocks to see below us, on a long, sweeping slope of bald land, four big-horn sheep standing out like so many sentinels of that life amid the surroundings which stirred our very souls.

Within the last two years the State of Wyoming has received from $20,000 to $25,000 from the sale of game licenses, and the cost of administering the game department has been about half that amount. The purchase of residence licenses at $2.50 and the non-residence license at $50 each is, of course, a small portion of the money actually spent in the hunting region. It has been found that parties going out in the immediate neighborhood for deer would average from $30 to $36 each, while in the more attractive big-game sections non-resident parties, amounting to from 1 to 200 yearly, would spend from $400 to $600 each.

The State of Wyoming has a law prohibiting the leaving in the woods the meat of elk and deer killed. This law brings into the communities of the game regions large amounts of meat each year. In one year the meat brought out of the woods at Cody alone, and valued at a nominal sum per pound, reached a sum greater than that derived from the sale of all game licenses for the year.

A small number of elk were shipped into the Estes Park district of the Colorado National Forest at the expense of the people of Estes Park, the Biological Survey, the Burlington Railroad, and the Forest Service. These elk were to be seen in one corner of the park, and last season the money paid by guests for teams and saddle horses to make the trip to see these elk was a sum above the cost of placing them in the park; so it can be proven beyond a doubt that game culture by the State and the Federal government can be made to pay, in the boldest sense of the word.

Not long ago a member of the Forest Service said to me: "Your argument about the value of game is good, but you have not shown in a single case that the Forest Service derives a cent; all the money or benefit goes to the State or communities of the game region, while you are spending money for these game plants, and you are giving the rangers' time, which means money, to assist in the enforcement of the law." There is a protection Forest in Colorado upon the watersheds of streams, the flow from which has very high value for irrigation, and one of these streams furnishes the water supply for a city of more than 200,000 inhabitants.

This Forest costs $45,000 yearly to administer. The receipts are very small and there is no prospect of the receipts ever reaching the sum of the cost of administration. The prime purpose of the Forest is to protect these watersheds, though the Service does not get a cent from irrigation. It surely must be possible to give attention to game culture as a secondary matter in forest protection, particularly when such time given to game culture does not detract from, but adds to, the standard of forest protection and renders the National Forests of greater value to the States and Nation.

All through the National Forests there are numberless areas where big game was once abundant and from which it has been driven out or killed through lack of protection. There is every reason to believe that game will thrive upon the majority of these areas if plants can be made upon them and the animals allowed to adjust themselves to the conditions and increase. Some study and careful work will be required if the capturing of specimens, transportation, and planting is to be done successfully. The question arises as to whom this should naturally fall. In many cases the specimens will be transported from one State to another. Difficulties will arise from this cause, for most of the States have laws that prohibit the shipment of game animals out of the State except in exchange for others. This does not offer a great difficulty, as the matter appears to be largely in the hands of the governors, who can give permission for such out-of-State shipments. The whole question is a new one, and, of course, there is a possibility of making the mistake of placing animals on areas where the natural conditions will cause them to become a nuisance to farmers and ranchmen, either by summering in their grain or hay areas or wintering around their haystacks. Considering the necessity of care and experience, I think the work should be initiated by the Biological Survey and the Forest Service in co-operation with the States. The Forest Service, under the direction of the Biological Survey, can collect most readily and at least cost data upon areas to be stocked and locations where specimens can be captured. The Biological Survey can then take up the capturing and shipment. Forest officers might be used for this work, but it should be carried forward under the direction of the Survey.

There should be an appropriation for this work, say $20,000 yearly, to be expended upon a one-third or one-fifth basis. In other words, the Federal government funds should be used where the State, people of the communities, railroads, and game protection associations, etc., will put up two-thirds or four-fifths of the costs, and the States furnish the specimens where they cannot be furnished by the Federal government, or where they can be secured to best advantage from the State. Ready response will be received to such a move. The only thing required is decisive action upon the part of the Federal government to show its practicability. Now comes the question of the chance of success of such game planting. It is repeatedly pointed out that about 49 out of every 50 plants of this nature, with game birds particularly, have been failures. This is true, but in nearly every case it will be found that these failures can be traced to a total lack of preliminary study that has resulted in placing species under climatic conditions not suited to them,

or lack of protection after the plants are made. The last I consider the main cause of failure. I have been told that it is useless for the Federal government to go to the expense of placing game animals in regions where the citizens have so little respect for the law that they will kill the specimens placed there for breeding purposes; that in most States the machinery for the enforcement of the law is entirely adequate, even where the laws are good and would offer protection needed if enforced.

The people are ready and willing to protect the game. The present abuse of the game laws and destruction of the game comes from a feeling that it will not be protected, and that he who is on the ground should take all he can. The people want to see the game protected and will assist any honest and sincere move upon the part of the authorities to this end. It is true there is at present a wholesale disregard for the game laws in the game States. However, it must be remembered that the States are largely responsible for this because of the odium which has grown up around the position of game warden through the class of men appointed to that office. Political appointees to this position, absolutely lacking in energy to look after their own interests, who went into communities and gave it out that they enjoyed fresh meat and disliked bacon at all times of the year, gained only the contempt of the citizen who, prompted by a desire to get his share if the game was going, killed in season and out of season. Where an honest warden attempted to enforce the law, he was branded with character that the worthless wardens had created in the minds of the citizens by reputation, and a justice of the peace would turn an offender free, even where the evidence was absolute and the prisoner caught red-handed.

On the head of Green River, in Wyoming, where big game is plentiful and ranches are few, and where the law-abiding citizen who needs fresh meat kills an elk at any time of year, there was a ranger who, under the Forest Service agreement with the State, assisted in the enforcement of the game laws. This ranger liked the job and enforced the law without fear or favor. He got convictions before the justice of the peace. who became nervous at the thought of turning a man loose when the evidence against him was good. The people helped and respected the ranger for his stand; all the hunters that went into that section knew the ranger and knew that the game law was the game law. The ranger was transferred, a new man was put in his place, and a game warden was placed on the river by the State. He is the kind that has done much to give the position its present reputation. The ranger who is not particularly heavy on this question has left the game business to the warden,

and the very people who helped the old ranger are raising hobs with the game.

Some elk were shipped, in co-operation with the Biological Survey, the citizens of Aspen, Colo., the Midland Railroad, and the Forest Service, to the Hunter Creek district of the Sopris Forest, just above Aspen. Last spring, when the weather was bad, a man came to town and told another man he had heard some shots and had seen an elk running away from a haystack. The forest supervisor heard the story, so he took a ranger and the sheriff and went to the scene of the shooting. He found the elk's track where it had run from the stack; he found the bullet marks in the snow; he found man tracks and empty rifle shells; he measured the man tracks and counted the nail imprints and followed these tracks to a ranch house, where he found shoes to fit the tracks and a rifle to fit the exploded shells picked up at the scene of the shooting. Shells exploded in this gun had certain marks upon them just like the empty ones picked up at the scene of the shooting. On the strength of this evidence two Frenchmen, who hid behind an ignorance of the English language and were represented by the ablest lawyer of the region, were tried and convicted upon circumstantial evidence. The Elks Lodge of Aspen wrote an open letter to the forest supervisor and the ranger thanking them for what they had done in this case and pledged support of the lodge to the forest officers in game protection. In the White River Forest there is a "Dude Ranch," the owner of which has for years violated the game laws by allowing his guests to kill game out of season. His premises were searched at an opportune time this past year and he was tried and convicted of killing an elk. The judge in charging the jury said he should be given the full extent of the law, and all violators of the law relating to game should be treated in like manner.

These cases I have cited spell one thing to me: The people want the game laws enforced and will give the keenest support to any honest move to that end. Here again the Federal government must come to the front. I have no patience with those who advocate that the Federal government should follow the State in this matter. The Federal government must stand ready in game protection, just as she does in everything else, to assist the State to better things where she cannot help herself. The States are glad to get suggestions from the Forest Service upon game legislation; they are glad to get its assistance in the enforcement of the game laws. Much improvement can be brought about by a frank criticism under an existing agreement of the game wardens appointed by the State that are not doing their duty. This will lead the way for

game protective associations and citizens to take up this same question with the States. In this way, and in this way only, will the standard of the personnel of game wardens be raised to that point where such men will receive the respect of the people and be able to enforce the laws.

In outlining a policy, then, let us consider the game upon the same dollar-and-cents basis as the domestic stock and its actual value to the public. In place of marking time behind the State, let the Federal government point out means for better game laws and machinery to enforce them.

THE ENTOMOLOGICAL ASPECT OF SLASH DISPOSAL

BY RALPH HOPPING

Contributed

There is one protection factor in slash disposal that Mr. Koch in his article, "The Economic Aspect of Slash Disposal," in the July, 1914, number of the Proceedings of the Society of American Foresters, fails to consider. This is the danger of an insect infestation resulting from the breeding of large numbers of destructive bark borers in the unburned refuse from timber sales, such as cull logs, tops, and limbs.

That the danger from slash left on the ground should be considered from all sides of the question is obvious, and that the danger from insects is not negligible is recognized by foresters the world over. While the very small limbs in France, Austria, and Germany may not always be piled and burned, the utilization of all tops and limbs is so thorough as to practically eliminate this danger. The very small branches and twigs do not breed any very dangerous species. In America, however, the absence of settlers and distance from market precludes this thorough utilization. Logs are seldom used under 10 feet in length and limbs not at all, except in cases where they are used for fuel in logging engines or in the rare instances where cordwood sales are possible.

Mr. Koch and Mr. Mitchell[1] have very ably considered the cost and necessity of slash disposal from a fire-protection standpoint. That the protection of our forests from insects is probably of as great importance is beginning to be recognized by foresters in the United States and Canada. I will cite one instance of damage from insects, resulting from unavoidable slash, as an illustration of the importance of this phase of the question in America.

During the winter of 1912-1913 the southern part of the Sierra Nevada Mountains, extending from the Merced River on the north to Kings River on the south, was visited by a storm which caused a large amount of snowbreak, especially in the pole and sapling stands. This slash bred a bark borer (*Ips confusus*), which is very destructive to young growth of western yellow pine and the tops of mature trees of the same species. The beetles increased in this slash to such an extent that in the spring and summer of 1914 groups of 75 and 100 dying trees were not uncommon. Strenuous efforts have been made to check this epidemic in some of the

[1] **Proceedings of the Society of American Foresters, Vol. VIII, No. 3, 1913.**

more important commercial stands, at a cost of approximately $5,000. What the ultimate cost will be it is impossible to estimate at the present writing. This was a natural cause, and only serves to illustrate the immense damage resulting from fresh material which is not promptly burned, or at least before the broods escape to near-by standing timber.

Settlers and commercial activities in our wooded areas, especially in the western United States, have added another cause for epidemics of insects in our forests. Visitors and residents to these sections are continually reporting the increase of dying timber due to this cause. Prof. E. P. Stebbing,[2] a well-known English forester, says:

"Experience has shown that in countries where very large tracts are covered with a single species of conifer, such, *e. g.*, as is the case in America and to a lesser extent perhaps in India, uncontrolled fellings have resulted in the most disastrous infestations of bark-boring beetle pests."

Unburned slash constitutes "uncontrolled fellings." I do not mean to state, nor does Professor Stebbing, that all uncontrolled fellings start epidemics, but that many of them do, and that the damage and consequent loss is so large that it will greatly exceed any expenditures for slash disposal. Certain investigations in California have proved that the annual loss of timber from the depredations of forest insects has increased from year to year. If only natural causes, such as snowbreak, windbreak, and climatic conditions, were responsible, the loss would probably not exceed that in the past. This loss, however, has been augmented by freshly cut, unburned material.

It has been the general policy on the National Forests and on some private holdings to burn all slash, but this slash has not always been burned at the right time. In order to prevent the insect broods which destroy standing timber from escaping, the slash must be burned before the brood escapes. Where these broods have escaped from public and private operations resulting in slash, small epidemics have started wherever the conditions were favorable. An instance of this is the Cox timber sale on the Plumas National Forest, where an epidemic started from the cull logs and slash, which killed a large percentage of the standing timber on the hillside above the mill the following year.

An epidemic has just appeared in the eastern Lassen National Forest along the right of way for the Fernley and Lassen Branch of the Southern Pacific Railroad. This started in the logs and slash felled in clearing for construction. Unless controlled, these epidemics increase from

[2] Indian Forest Memoirs, by E. P. Stebbing. Vol. III, Pt. I, page 1, 1911.

year to year and are often augmented by broods from other freshly cut material.

The infesting species is often different, due to different species of trees or parts of trees. Thus a cull log or top of yellow pine (*Pinus ponderosa*) breeds the western pine beetle (*Dendroctonus brevicomis*), the most destructive beetle to yellow pine on the Pacific coast. Tops and limbs breed another very destructive species, an engraver beetle (*Ips confusus*), killing tops of trees and young growth. No matter what the species of tree the slash resulted from, that slash breeds under ordinary circumstances the insect or insects destructive to standing timber. The annual loss from this cause alone far exceeds any cost incurred from the burning of the slash at the proper time. Therefore, the consideration of the burning or non-burning of brush must be taken up from a broad protection standpoint and not from the standpoint of fire risk or cost alone.

DOUGLAS FIR AND FIRE

BY C. S. JUDD

Contributed

The extensive even-aged forests of almost pure Douglas fir on the Pacific slope in Washington and Oregon owe their existence to fire. In other words, Douglas fir exists here only as a temporary type, which paradoxically would have utterly vanished long ago had it not been for the purging effects of holocaustic fires.

Neither a true fir, nor a spruce, this "yew-leaved false-hemlock" is imbued with peculiar characteristics which are in consonance with its outcast nature. Douglas fir demands an unhampered field when reproducing itself as a forest and, intolerant of shade, asserts an independence by refusing to germinate on humus and rotten wood and grow up in the shade of other trees. It is, however, comparatively short-lived and independently cannot hold out as a forest against its shade-enduring relatives.

Given a free germination bed, Douglas fir, with its vigorous reproductive capacity and asset of rapid growth, will outstrip its coniferous associates at the start and hold the field as an even-aged, dark, moisture-holding forest up to a certain point. But after about 200 years or more of dominancy it will begin to disappear and yield to types of other species unless an opportune fire comes to its rescue. To be sure, individual Douglas-fir trees as old as 739 years have been found, but forests of this species begin to deteriorate after two centuries of healthy growth, and, unless fire interferes, are, in another 200 years or more, completely displaced by more tolerant species that have been lurking in the shade as an understory ready to occupy the opening in the forest canopy which they instinctively seem to know will come.

At first the failure of Douglas fir is slow; here and there a mature tree attacked by decay weakens and dies, the infection spreads, and ground rot sets in. Light is thus admitted to the understory, which responds to the stimulus and soon occupies an equal crown space with the original stand. From then on the proportion of western hemlock, western red cedar, the true firs, and sometimes Sitka spruce increases and Douglas fir is gradually crowded out until perhaps only a few trees remain. These too will finally disappear or will exist in the stand of

new species only as dead stubs, decaying logs, or a mere pile of bark until obliterated by time.

Excellent examples of even-aged Douglas fir stands in all of these successive stages may be found abundantly on the National Forests west of the Cascade Mountains in Washington and Oregon. On extensive areas one may see young thickets of pure Douglas fir that are almost impenetrable; on other areas even-aged stands of Douglas-fir poles, and on still others tall forests of straight, well-cleaned piling. In the older forests of sawtimber size the slow-growing understory becomes noticeable, and finally, where Douglas fir has become senescent, hemlock, firs, and other species vie with the pioneer tree and begin to monopolize the ground.

From the Wind River Experiment Station to Red Mountain, on the Columbia National Forest in Washington, one can ride along the Racetrack trail for at least 8 miles through a splendid, comparatively pure, even-aged Douglas-fir forest about 75 years old. The best stand of Douglas-fir timber that the Forest Service has thus far worked up for sale is on Winberry Creek, on the Cascade Forest east of Eugene, Oregon. Here there are 16,200 acres, carrying a total volume of 1,176,000,000 board feet, 88 per cent of which is Douglas-fir timber, represented on different parts of the area by several distinct age classes. One of these covers 1,636 acres and supports a thrifty stand of Douglas fir 200 years old, which runs 123,000 board feet to the acre. Of the total volume of 202,000,000 board feet 90 per cent is Douglas fir and the remaining 10 per cent western hemlock, western red cedar, and Amabilis fir.

Good examples of the almost complete replacement of Douglas fir by hemlock, red cedar, and grand fir are found on the Snoqualmie National Forest in Washington, where only 29 per cent of the estimated total volume of timber on the Forest consists of Douglas fir. On the Washington Forest to the north it is estimated that only 16 per cent of the total stand is of this species. Dodwell and Rixon's cruise of the Olympic Forest in 1889 showed that Douglas fir formed only one-fourth of the total volume of timber, and that on some townships, especially in the rainy belt, this species was entirely lacking.

The results of Forest Service timber reconnaissance have disclosed the remarkable paucity of Douglas fir on the drainage area of the South Fork of the Stillaguamish River on the Snoqualmie Forest. On National Forest land, in T. 30 N., R. 8 E., Douglas fir constitutes only 3 per cent, and in the township to the east only 5 per cent of the total volume of timber. Here sequent species have so completely replaced the original stand that, looking south from the Silverton Ranger Station, one may

see only a few remaining veteran Douglas firs, with open, bushy crowns, overtowering the hemlock and red cedar on the steep slopes across the river. In other parts of this same valley one may travel for miles and the only sign of Douglas fir will be the familiar bark on windfalls, some of the material perhaps being still sound enough for lumber, or rapidly deteriorating snags of large diameter. The timber sale at Gold Basin of 26,000,000 feet included an area which supported large western red-cedar trees from 1,000 to 1,500 years old, and a younger uneven-aged stand of hemlock and Amabilis fir, but not a single Douglas-fir tree. The Oso Logging Company sale on the same forest included a stand of a few veteran Douglas fir and cedar and an understory of mostly small hemlock, and the logging crew were wont to cheer with delight whenever a rare Douglas-fir log came to the landing in place of the usual small hemlock and cedar junk. It is noteworthy that in these stands where Douglas fir is scarce or entirely lacking very few evidences of fire are ever found.

Let us see now what agency has intervened and prevented Douglas fir from becoming extinct as a forest type. In order to maintain itself as the dominant species in a forest when senescence has been reached, Douglas fir must begin life anew. This can happen only if a free germination bed, preferably mineral soil, is furnished and if an abundance of light is made available by the removal of the forest of tolerant species. The only agent that can accomplish this satisfactorily is fire. Of course, fire might be introduced into Douglas-fir stands at any time in their life cycle; but in the younger stands of this species it makes little or no headway, because the close-standing trees, as a rule, form a dark forest, free from inflammable underbrush, which keeps the ground damp and fosters moisture. There are many familiar instances of how fires in Douglas-fir slash have died out when they reached young green stands of this species.

After Douglas fir begins to drop out of the forest, the crown canopy is broken, and the increased light supply admitted to the ground stimulates the growth of inflammable underbrush and dries out the decayed litter and humus on the forest floor. A fire comes along at the end of a long dry season, and what happens? It ignites this inflammable litter and soon spreads broadcast. It smolders in the thick layers of duff perhaps for months; it works underground to break out again in other places, and it finally consumes the roots and kills the trees. It may even be led up the trunks by the exudations of pitch from diseased trees; so that if there is a strong wind blowing, a severe crown fire develops.

The result is that in this purging conflagration the less fire-proof hemlock, cedars, firs, and spruce, with their thinner bark, are usually entirely

killed, while Douglas fir, with its thick, protecting bark and perhaps an accumulation of damp exfoliations of bark around its base, suffers the least; and some trees escape entirely the effects of the fire. The objectionable forest of other species in this manner is destroyed, the forest floor is bared for the reception of seed, and here and there a living Douglas-fir tree remains to cast seed for the new forest crop. If these trees be very old and about to die, they obey the familiar biological law and produce an unusually large amount of seed. Traces of these mother trees may be found in most stands of young, even-aged Douglas fir, and may be likened to a barnyard of hens, each surrounded by a crowded brood of little chickens. If the denuded area is very large and no seed trees survive, the fire reforestation proceeds more slowly by seeding in from live trees at the edges of the burn.

In this manner, where fires are most severe and the ground cover burned off so that mineral soil is exposed, Douglas fir, with its vigorous reproductive capacity, regenerates itself to the almost complete exclusion of other species. The resulting forest is of comparatively pure Douglas fir; and, although variations in this life history may sometimes take place, fire has thus been the main controlling factor over the distribution of pure forests of this species and the leading agent in continuing the rotation of even-aged Douglas-fir crops.

Let us now consider the cause of these fires in the past, for evidences that these ancient fires have occurred may almost always be found in any pure stand of Douglas fir in the form of blackened stubs and charred fragments and knots. It has also been reported that excavations for skid-road grades in Douglas-fir forests have disclosed layers of charcoal which mark one or more of these old burns. Just as one can tell by examining the fire-scarred annual rings in the big trees of the Sierras that forest fires occurred in the years 245, 1441, 1580, and 1797, so can one determine that extensive and severe forest fires occurred on the Pacific slope, in Washington and Oregon, 12, 32, 130, and 260 years ago, by ascertaining the age of the pure, even-aged stands of Douglas fir in this region.

Indians are blamed for a great many of the forest fires in the past, and it is probably true that they set them frequently to drive game, facilitate hunting, and permit the growth of berries. But one should look further back into world history, beyond the time when man first inhabited this globe.

It is probable that forest fires have occurred ever since there were forests, and, as Plummer pointed out in Forest Service Bulletin 117, wood found in the Pleistocene formation showed the effect of fire, and charcoal has been found in the peat bogs of North America and New Brunswick, some of which are from 2,000 to 3,000 years old.

As all highways led to the ancient capital of the Romans, so all indications seem to point to the obvious conclusion that lightning must have been responsible for starting a large share of these forest fires in the past. But extensive fires resulting from lightning were evidently not very frequent and occurred only when all conditions were extremely favorable.

At the end of a protracted dry spell the forest became so dried out that only a spark was necessary to ignite the inflammable material. An electric storm in the higher mountains swept over this desiccated forest; moss-covered trees, struck by lightning, flashed up like ignited tissue-paper, and soon the whole region was in flames; or perhaps a lightning stroke was conducted down a tree and started a fire in the humus at its base. If a strong wind was blowing, especially from the east, a raging crown fire was developed and was stopped only by the first rains of fall or some natural barrier. Thus the Coos and St. Helens fires of 1868 each covered 300,000 acres in Washington and Oregon, and the Columbia fire, in 1902, devastated 604,000 acres in these two States. All of these started in the month of September, at the end of a long dry spell.

Plummer's assertion in Bulletin 111 that "lightning is one of the chief causes of forest fires" is substantiated by the record of fires on the National Forests in Washington and Oregon, kept for a period of eight years. While any such record is not absolutely reliable, because all fires are not detected and the cause of some never ascertained, the following record for the region in which most of these pure stands of Douglas fir occur shows beyond doubt that lightning has been the chief cause of the fires which have been instrumental in renewing Douglas-fir stands in the past and preventing them from becoming extinct as a forest type.

Causes of forest fires on the National Forests in Washington and Oregon for the eight calendar years, 1906 to 1913

Cause.	Number of fires.	Per cent.
Lightning	1,059	25
Campers	925	22
Unknown	894	21
Railroads	498	11
Incendiary	328	8
Brush burning	247	6
Miscellaneous	246	6
Sawmills	40	1
Totals	4,237	100

Very often lightning will strike in an unfrequented region, will set fire to the timber, burn over a small area, and then die out, without ever being discovered or reported, and it is estimated by one thoroughly familiar with this subject that probably only 30 per cent of all lightning fires are ever reported. Aside from this, however, it is probable that one-half of the fires whose origin is reported as "unknown" are due to lightning. It is reasonable, therefore, to assume that at least 35 per cent of all reported fires in this region are due to lightning.

THE MANAGEMENT OF ENGELMANN SPRUCE–ALPINE FIR STANDS

BY JOHN W. SPENCER

Contributed

The management of any kind of a stand of timber on a National Forest is controlled by several factors—the nature of the region in which the stand occurs, the objects for which the forest was created and is administered, the character of the timber itself, and, finally, the markets for timber products.

The Battlement National Forest is characterized by flat-topped mountain ranges or extensive mesas, with very steep and often precipitous sides. The ranges have an average elevation of over 10,000 feet, and a few peaks run up to 11,000 feet or over. The mountains slope abruptly down to a series of brushy foot-hills, which in turn give way to broad stream valleys. The valleys are well settled and the residents carry on an extensive business in stock-raising, fruit-growing, and general farming. These ranches depend for their water on the streams rising in the surrounding mountains. It was for the purpose of protecting the watersheds of these streams that this forest was created. The upper reaches of the mountains receive a heavy annual precipitation of rain and snow. No figures are available, but it is estimated that this precipitation is about 30 inches yearly. The timbered sides of the mountains and the brush-covered hills and gulches catch and retain this moisture and keep the streams running the year around. For this reason the chief aim in managing stands is to keep the forest cover unbroken and to increase it where possible.

The only timber type of any considerable commercial importance is a subalpine type consisting of mixed stands of Engelmann spruce and alpine fir (*Picea engelmanni* and *Abies lasiocarpa*). Around the heads of streams and in the beds of some canyons at medium elevations Colorado blue spruce partially supplants the Engelmann. The spruce-fir type occurs on the tops and higher slopes of the mountains at altitudes of 8,500 to 11,000 feet. There is no upper timber-line. This type occurs on all slopes and exposures and on nearly all soils and under nearly all conditions of moisture. Sour, swampy sites seem to be the only locations where these species cannot live. The heaviest stands are found on north-

ern slopes and in the bottoms of canyons, where the soil is deep, cold, and moist. The composition of these stands varies from practically pure spruce to nearly pure fir, but taking the stands as a whole fir is by far the more abundant species. The majority of the stands are a mixture in about the proportion of 60 per cent fir and 40 per cent spruce.

The stands are all in the virgin state and contain large amounts of mature to overmature timber. A peculiar characteristic of this type is the occurrence of the timber in compact, isolated bodies separated by parks of varying size. These parks bear a growth of oak brush, grass, shrubs, and occasionally small aspens. The bodies of timber are small; very few of them cover over 200 acres. The largest bodies are found on the north slopes of the mountains, interspersed with patches of oak brush and aspen. On top of the ranges the timbered areas are widely scattered and are separated by open, grass-covered parks or meadows. Taking the forest as a whole, probably not over 40 per cent of the area within the altitudinal range of this type is timbered.

The wooded areas, as a rule, are very densely covered with a compact stand, averaging from 160 to 180 trees per acre. Occasional bodies bear 250 trees over 6 inches in diameter per acre. Both fir and spruce reach an *average maximum* size of 26 inches, and occasionally 36 inches d. b. h. The mature fir *averages* 18 to 24 inches and the mature spruce is somewhat larger. The merchantable stand as a whole has an average d. b. h. of about 16 inches.

All ages are represented in these stands and the areas occupied by the different age classes are in fairly proper proportion. Both species are short-boled, have a great deal of taper, and are inclined to be "churn" or swell butted. This last feature is particularly noticeable in the spruce. These characteristics are probably caused by unfavorable growing conditions of altitude, cold climate, high winds, and dense crowding.

The spruce is usually sound, even in the older-age classes, and shows only a slight amount of defect. The fir, however, contains a great deal of rot, dote, and other defects. The rot in the butts of the trees leaves great cavities, which often extend far up the stem. The young fir is usually sound, but as it grows older goes to pieces. It is very exceptional to find a mature fir that is entirely sound. Furthermore, the fir timber on cold, moist north slopes contains more defect than that on other exposures.

A great deal of standing and down dead timber occurs in these stands, averaging 1,200 to 1,500 board feet per acre. This dead timber is of all sizes, and the reason for its death is not evident. Probably it is due to excessive crowding, which lessens the available supply of moisture and

soil minerals for each tree. Some of the younger trees which have been suppressed cannot maintain their hold under these conditions of decreased sustenance. Some of the older individuals, whose vigor of growth has declined, succumb to the same unfavorable conditions. Much of this standing dead timber is merchantable and makes very fair dimension stuff and house logs.

Frequently stumps of trees long fallen and decayed are found, which show that some individual trees reached a much larger size in former times than they do today. Stumps with a diameter of 55 to 60 inches have been observed, while it is doubtful if there are any living trees today 40 inches in diameter. These large-sized old stumps are not exceptional specimens, but are found over all parts of the forest. Why these old trees should have been so large is not clear. Possibly in former times the trees occurred as separated individuals or groups rather than in large bodies, as at present. In such a case these old trees would have grown to great size, and then, being crowded by younger stands of which they were the progenitors, would die, decay, and fall.

The Engelmann spruce and the alpine fir are the most shade-enduring trees in this region. Of the two the fir seems to be slightly the more tolerant. Young trees of both species, however, can stand almost unlimited shade.

Reproduction in the forest as a whole is very abundant. One to two thousand seedlings per acre may be found in many stands. Alpine-fir reproduction is greatly in predominance in all sizes. The reason for this lies in the fact that underneath the standing timber there is a layer of duff of considerable thickness, through which the fir seedlings can strike much more successfully than the spruce. Spruce germinates best on bare mineral soil, and where this is found the spruce more than holds its own with the fir. Wherever the soil has been scratched up and the litter brushed aside, as around dislodged boulders and the roots of windfalls, the spruce takes possession. The spruce also seeds in more abundantly in the open parks. The soil here is more exposed to sunlight than that under the standing timber, is less thickly covered with litter, and gives the spruce seedlings a better foothold. Spruce seedlings require plenty of moisture to develop, but once started will grow and thrive on soils too dry for alpine fir.

Engelmann spruce and alpine fir are inferior species from the standpoint of lumber production. Both of them, and particularly alpine fir, have lumber that is weak, full of knots, and not durable. Boards from these species rot very quickly in contact with soil. However, there are no competing species of commercial value, and these two trees assume a

local importance commensurate with that of yellow pine in other localities.

The Battlement and its neighboring forests are the only source of timber for this region. For this reason a plan of management that will protect this supply and obtain the maximum quality and quantity of production is necessary. But, also, in any plan of management evolved for this forest the primary object must be to secure adequate watershed protection. The important agricultural and fruit interests of the valleys look to this forest for their water, and their supply must be safeguarded. To maintain and increase the quality of the sawtimber is a secondary but important object of management.

As mentioned before, both spruce and fir produce poor lumber, but of the two spruce is by far the more valuable. Spruce is stronger, clearer, and has much less defect than fir. Because of these points of superiority and because it does not go to pieces so quickly after maturity, spruce should be favored. It is very difficult, however, to formulate a plan of management that will favor the spruce and still carry out the main policies of the administration. There is no possible way of eradicating the fir quickly and completely without damaging the whole stand. Such a change must be brought about gradually.

A system of clear-cutting in strips, burning brush, preparing an artificial seed bed on the strips and allowing them to seed up from the standing timber alongside is the ideal one silviculturally. This would undoubtedly assure abundant spruce reproduction, provided that there were sufficient seed trees along the margins of the uncut strips. But market conditions, coupled with the danger of drying out and of windfall, eliminate this idea.

The only practical scheme is to use a form of the selected system. Under this system all of the merchantable dead timber will be cut. All overmature and decadent fir will be cut, in order to clean up the forest and to lessen the seed supply of this species. All of the mature fir timber that can be cut without opening the stand too much will be removed. Unmerchantable snags will be removed as completely as possible. Under present timber-sale policies the operators may be required to cut an average of four snags per acre. This number is large enough in most instances to secure the removal of the majority of snags.

Mature Engelmann spruce will be cut only where there are other spruce seed-trees to insure satisfactory reproduction.

Marking must be very lightly done around the edges of parks and along public roads. This is necessary to leave plenty of trees to seed up the open areas and to guard against windfall. Only those trees which

are a hindrance silviculturally should be removed. Isolated veterans in the parks are nearly always spruce and should be left. Ordinarily in an operation of this kind not over one-fourth to one-third of the stand should be removed. Both species are shallow-rooted, and too severe marking exposes the stand to drying out and to grave danger from windfall.

After the first cutting has been completed the remaining stand should consist of trees of three classes, viz: reproduction of both species; sound, healthy growing trees of both species; and a number of the older spruce trees, provided they are sound. A defective spruce should not be left unless it will last until the next cutting or unless it is very badly needed for seed.

In this system, as in all others, the first effect will be to release the young fir trees which have been suppressed, and for a number of years the fir will seem to be in predominance; but after the first logging has been done the forest canopy is opened up and the forest floor receives more light. Also the ground has been scratched up in the course of the logging and a seed bed especially favorable to spruce has been prepared. Although the fir saplings have been released and allowed to grow, the ground beneath has been taken by an increased proportion of spruce seedlings. As future operations take more and more of the fir and favor the spruce, the time will eventually come when the spruce will be the predominant species.

Marking for the first cutting must be conservatively done. It is better to have a stand of pure fir timber than none at all. The idea of this system is not to eliminate the fir entirely. In the first place, that would probably be impossible. Secondly, the fir is as good as spruce for protection purposes and these purposes must be given first consideration. But fir is the less valuable of the two species, and if the proportion of spruce can be increased and our ideas of watershed protection carried out, then this plan of management is justified.

The foregoing system contemplates the leaving of spruce trees for seed wherever they are needed. Many of these trees will necessarily be of large size and will represent a considerable investment. But if these trees are carefully selected and are not defective, they may be allowed to grow through one or more cutting periods before they are removed, and will appreciate rather than decrease in value. If every time the area is marked for cutting a number of trees of this class are left and a few of those left from previous cuttings are removed, some larger-sized and more valuable sawlogs will be secured as a portion of the yield. The leaving of these trees is primarily for securing desirable reproduction, but their increase in rate of growth after the thinning will very likely

be sufficient to make it also pay to leave them from the standpoint of timber production.

In lumbering under this system all brush should be lopped and scattered. After one winter's snows have fallen on this brush it is pressed closely down to the ground. Here it absorbs moisture and decays rapidly, and all fire danger from this source disappears within two or three years.

Piling brush in a spruce-fir forest is a mistake. Green piles cannot be burned, and by the time they have dried out sufficiently the ground litter and surrounding timber is also so dry that brush burning is very dangerous. Dry brush piles under a light fall of snow are the only ones that can be satisfactorily burned. On this forest, at least, such a combination of favorable factors has been very hard to find. As a result many piles are not burned, but are left in the woods to rot. This practice has not been satisfactory because only the bottom of the pile decays. In case of a ground fire these piles ignite and make a hot, concentrated flame that is very likely to start a serious conflagration. Scattered brush is usually moist, but if it does dry out and burn, it does not produce as hot nor as enduring a fire as the piled brush.

SUMMARY

In following out the foregoing plan of management the first trees removed from the stand will be the merchantable dead timber and the decadent living trees. Mature fir will be cut as heavily as is consistent with safety. Spruce trees will be cut only where they can be clearly spared. Timber along the edges of parks, along roads and tops of ridges will be marked very lightly or not at all, both for esthetic and silvical reasons. As all age classes, conditions of growth, of health, and of vigor are represented in this spruce-fir type, the chief aim in all marking is to improve the stand rather than to create a new one by reproduction.

The local demand on this forest for timber is heavy, and will become increasingly so as the country develops. As this demand increases, the markets will become less exacting and it will be easier to follow out these policies more exactly. In the course of the next twenty years practically all of the dead and overmature timber will have been removed, leaving a stand of thrifty trees of both species. When the forest reaches this condition, the demand for timber will easily be large enough to consume the annual output. From this time forward it will only be possible to cut yearly an amount equal to the annual yield. In order to secure a sustained annual yield marking within, the stand will have to be checked by

some controlling factor, such as diameter limits or crown spreads. However, it is better not to attempt to establish these limits until all of the overmature timber has been removed. As the stand approaches a normal condition this plan of management may be slightly modified to embrace these requirements. The fundamental principles of this plan will be the same in the future as they are in the present, viz., to keep the continuity of the forest cover unbroken, increase the quality and quantity of the yield, and favor the more valuable species.

Thus eventually we will have a forest from which the alpine fir has been largely eliminated, which will contain only healthy, thrifty trees, will furnish a steady supply of better lumber to the local markets, and at the same time will protect our watersheds more thoroughly than it does now.

In working up this plan an attempt has been made to formulate a scheme of management that will be intensely practical, one which a field officer can read over and then apply directly in the field. It is useless to prepare a detailed and intricate plan of management that will take care of all the contingencies of the future and expect to apply it successfully to an uneven-aged virgin stand.

A POSSIBLE MEASURE OF LIGHT REQUIREMENTS OF TREES

BY W. W. ASHE

Contributed

Several methods have been suggested for numerically expressing the comparative demands on light or the tolerance of shade of different species. While photometric measurements are easily secured, they require adjustment to a standard to meet varying light intensities. They show the light conditions within the forest, and while suited for measuring the shade tolerance of shrubs and under trees do not indicate the light requirements of the larger trees in stands. A more ready method of comparison for such trees based on mensuration data is relative height. This gives a numerical index which is readily obtained for individual trees and for different crown classes. While both diameter and height, which are the factors considered in determining relative height, are influenced by the shade tolerance of a species, the capacity of a species to endure crowding of its crown at a designated age is a better indication of its demands on light. The relation between the cambium surface of the stem and the surface of the crown of dominant trees would seem to afford a reliable basis. This furnishes the proportion of growing tissue on the stem to the chlorophyl surface exposed to direct sunlight. The approximate relation is readily secured for trees at all ages except small seedlings. The cambium surface of the stem is regarded as a cone, its base the diameter breast high of the tree inside the bark, and its height the height of the tree, while the surface of the crown is regarded as that of a sphere having a diameter of the crown space. By establishing this ratio between cambium surface and surface of the crown in stands at different ages and on different quality sites either for the dominant trees or for the crown classes which receive direct light, series are obtained which should express the relative demands on light for a species at different ages. This relation might be called the index of shade tolerance and should be comparable between different species at the same age. The variation in this relation with age and quality site for dominant trees of *Pinus tæda* L. is shown by the following table:

Age of stand.	Quality I.		Quality II.		Quality III.	
	Approximate average b.h. diameter of dominant trees.	Index of tolerance.	Approximate average b.h. diameter of dominant trees.	Index of tolerance.	Approximate average b.h. diameter of dominant trees.	Index of tolerance.
Years.	*Inches.*		*Inches.*		*Inches.*	
10	5.0	7.0	....	....	....	....
15	6.1	7.1	5.4	7.5	4.9	9.1
20	7.7	7.2	6.6	8.0	6.2	9.6
30	10.4	7.3	8.8	8.7	8.2	11.1
40	13.2	7.6	10.8	9.1	10.0	11.4
50	15.7	8.0	12.8	9.5	11.7	11.9
60	17.4	8.5	14.5	10.0	13.1	12.2
80	20.0	9.4	17.0	11.1	15.4	13.1
100	22.3	10.6	19.1	12.1	17.0	13.9
120	24.0	11.5	....	....	....	....

As established by these figures, a tree of this species at 15 years of age on Quality III has the same tolerance as at 35 years on Quality II, and at 70 years on Quality I—that is, the same surface of crown space per unit of cambium seems to be required at these ages for the growth of the dominant tree. Demands on light are shown to increase with age and to be greater on the poor-quality sites.

THE CLINOMETER ON FIRE LOOKOUTS

BY DONALD BRUCE

Contributed

There are three methods in common use of locating forest fires from lookout points. The first depends wholly on the lookout man's knowledge of the surrounding country. In the second he is supplied with a compass or oriented map and alidade, and reports fires by their bearing and estimated distance. Lastly, if the same fire is seen from two lookout points, the intersection of the bearings from them gives (theorectically) the exact point. Only the last method can lay claim to any degree of precision, and even this often fails for three reasons: (*a*) Lookouts are, in many cases, too scattered to insure that every fire be seen from at least two stations. Under certain topographic conditions, the expense of the many lookouts needed to insure dual observation of fires in their early stages is considered practically prohibitive. (*b*) When two lookouts see a fire, one sometimes sees the base of the smoke column, while the other sees a higher point as the column rises from beyond an intervening ridge. The intersection of the two bearings thus taken is sometimes surprisingly in error if the smoke column is drifted by the wind and hence not vertical. (*c*) Two entirely distinct fires in the same general region may be seen and mistaken for one. This is particularly common in the case of lightning fires, where an electric storm often ignites a number of dead trees, etc., within a very few miles of each other. The errors introduced through this mistake may, of course, be tremendous.

One additional instrument, however, makes possible, in many cases, a fairly precise location of a fire from a single point, provided a topographic map is available. This is a clinometer for determining the vertical angle of the line of sight to the fire, or the "dip." The azimuth bearing of the fire determines the vertical plane within which it lies, and obviously, the vertical angle establishes a single line within that plane. This in turn intersects the earth's surface at a definite point, and with a good contour map the determination of this point is easy and reasonably certain.

The task of the lookout is not difficult. In addition to his oriented map and alidade, he is furnished with some simple clinometer, and he

takes and reports both the azimuth bearing and the dip of the base of the smoke column seen. The receiver of the report must lay off the reported bearing on his office copy of the topographic map and determine

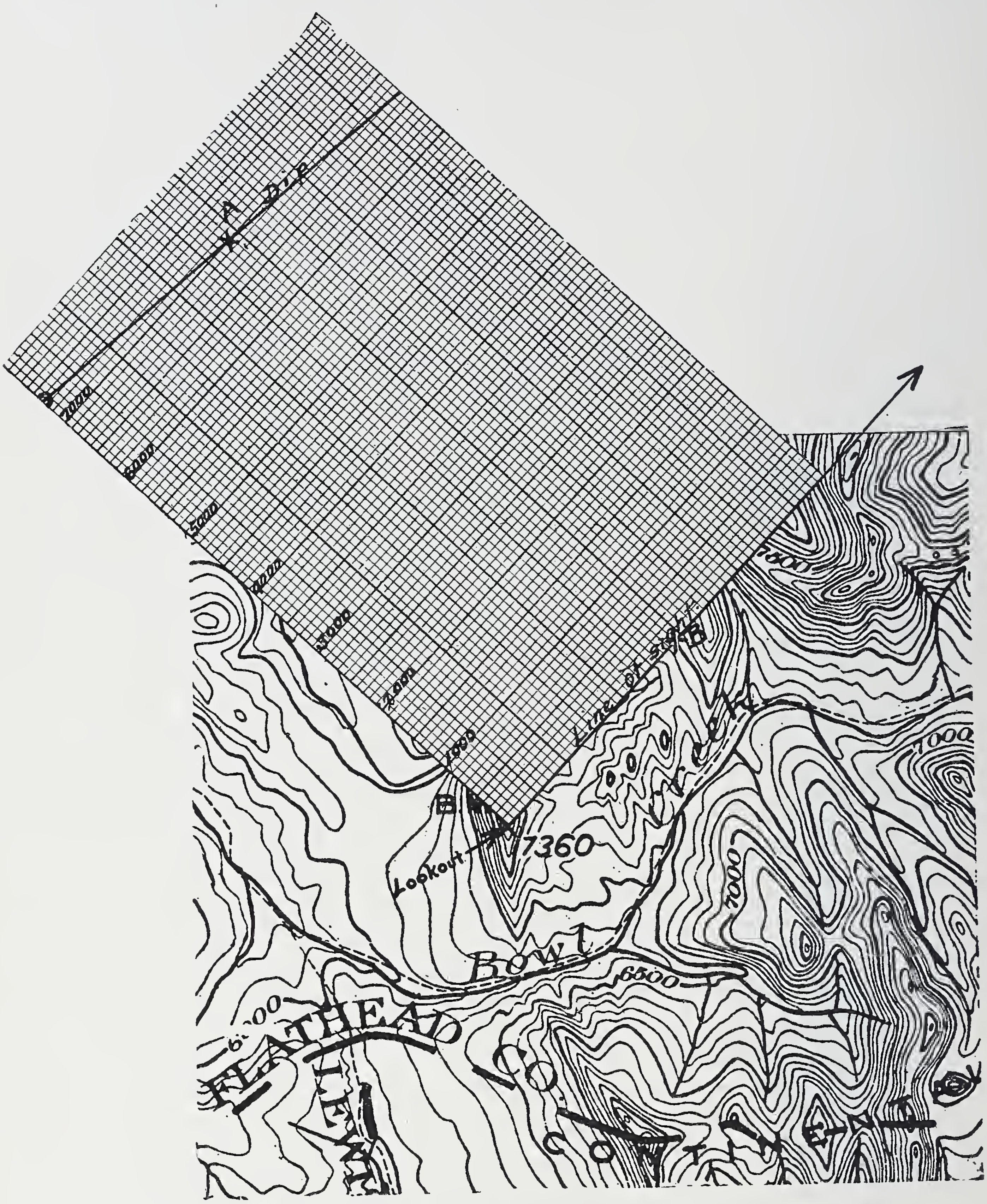

FIG. 1.—*A and B agree in elevation, indicating B as location of fire*

the intersection with the earth's surface of the dip reported along that bearing.

This may be done in two ways. The first and simplest is to plat on cross-section paper the profile of the topography along the given bear-

ing, lay off a line of the required inclination and note the point of intersection of the latter with the profile. This is unnecessarily laborious, however, and the second method is preferable. In this a piece of cross-section paper is thumb-tacked to the map with its axis of ordinates lying along the given bearing. The abscissæ then represent horizontal distances in accordance with the scale of the map and the ordinates' elevations. The lookout point is determined at its proper elevation directly over its location on the map and from it the dip line is drawn. The

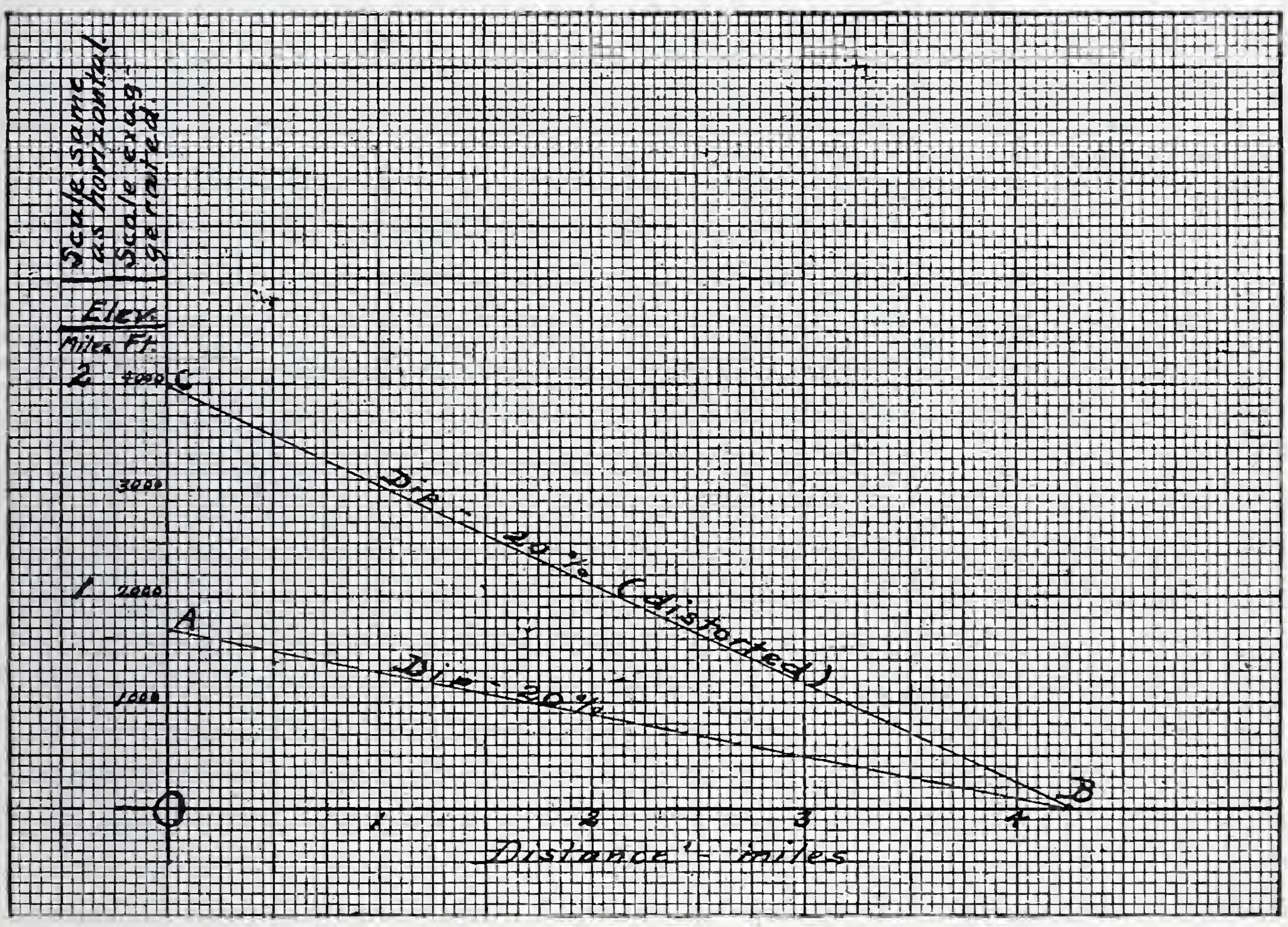

FIG. 2.—*OA, height of lookout; vertical scale same as horizontal. OC, height of lookout; vertical scale exaggerated to make contour interval agree with smallest division of co-ordinate paper.*

elevation of this dip line opposite any point on the earth's surface is its ordinate at that point, and the first point where this ordinate agrees with the contour elevation on the map directly beneath it is the point sought. Figure 1 illustrates the process. A slight complication is introduced where cross-section paper cannot be obtained which is divided to agree with the scale of the map. Only the vertical scale is important, but the smallest division here should be equal to the contour interval. Without this, an assumption to this effect may be made with any cross-section paper, although the use of different scales for horizontal and vertical

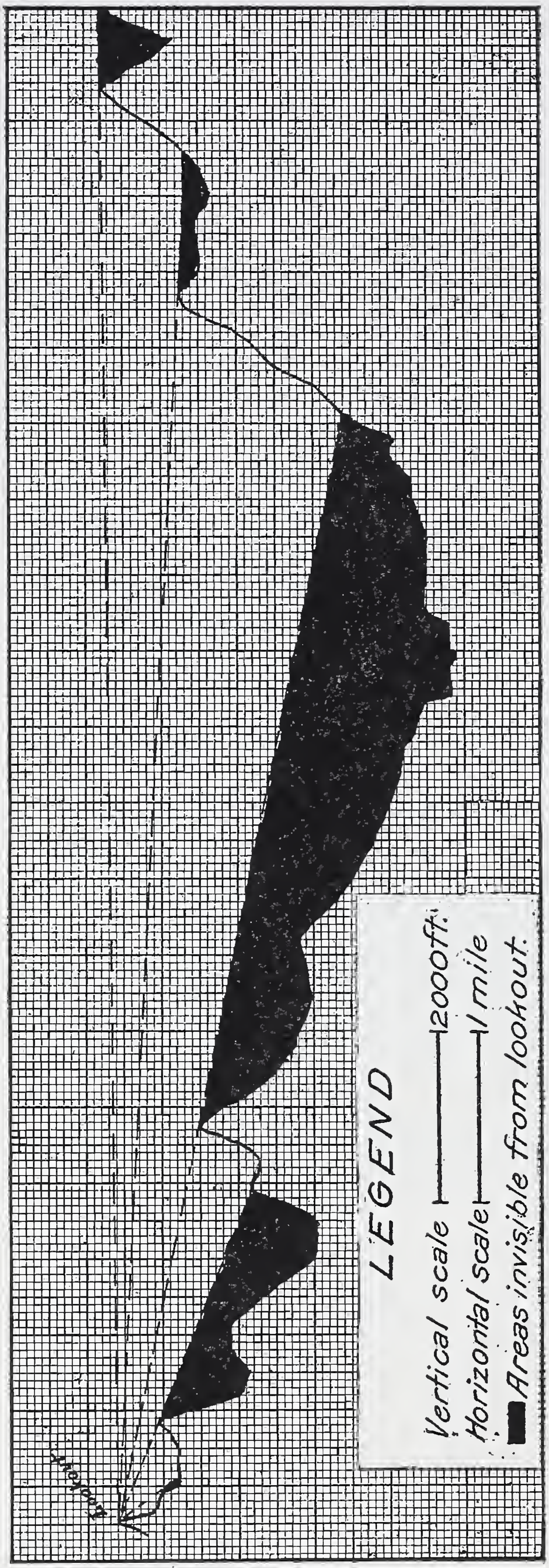

FIG. 3

distances is thereby involved. This will distort the position of the dip line. The position of this distorted line may, however, be readily obtained as follows (see figure 2): Enter on the cross-section paper the exact height of the lookout (A), using the same vertical as horizontal scale (its height may be read off directly from the scale of the map). Draw the required dip line (AB) from this point, using a protractor if given in degrees and a scale if given in per cent, and note the intersection (B) of this line with the base line or axis of ordinates. Enter the height (C) of the lookout, using the exaggerated vertical scale, which is necessary to make the contour interval coincide with the smallest division on the cross-section paper, and connect this point with B, the resulting line (CB) being the distorted dip line required.

It is advisable to prepare sheets of cross-section paper in advance for each lookout point, having the radiating dip lines for probable values already entered, thus saving some little time and eliminating the chance of error at a time when minutes count most.

The principal sources of error in this method of fire location are as follows: A, incorrect maps; B, incorrect readings or reports by lookout men; C, in-

strumental errors. The amount of error due the first cause varies, of course, widely, but the best U. S. Geological Survey map work has proven entirely satisfactory. Incorrect readings or reports are not to be considered too seriously, since there is no more chance for error here than in the azimuth reading. Instrumental errors depend, obviously, on the instrument used. The question is whether readings may be taken with sufficient nicety to permit reasonably close location. It is evident that the optimum conditions are: (*a*) a high lookout; (*b*) a fire occurring

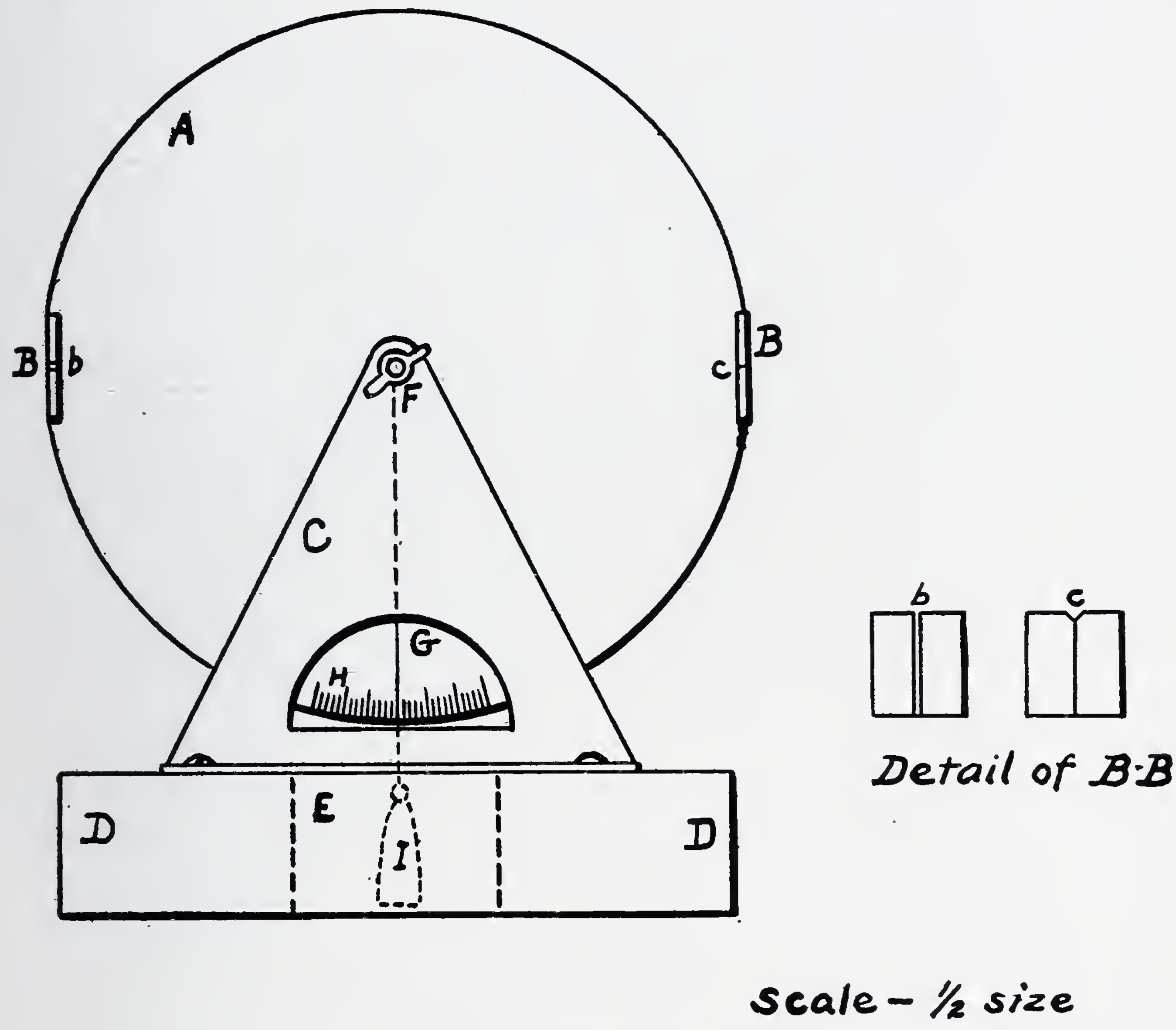

FIG. 4.—*Lookout Clinometer*

A, brass disc. BB, sights, formed by turning up at right angles lugs on A. Narrow slit sawed in one (*b*) and V notch in other (*c*) form sights. C, Standard-sheet brass. Back standard similar, but opening G omitted. D, wooden base. E, cavity in base for lead plumb-bob, I, suspended by silk thread. F, wing nut for restricting motion of disc within standards. Similar nuts on reverse side. H, scale.

on slopes facing the lookout point, and (*c*) at a short distance. If the error contained within the smallest possible reading on a simple and cheap clinometer be calculated for the low lookout overlooking flat country at a considerable distance, it will appear inordinately large; but, fortunately, lookouts are usually on the highest available points, their

range of effective vision is comparatively limited, and, most important of all, the country seen is a series of slopes facing the lookout, the reverse slopes being hidden. Figure 3 is a characteristic profile of the territory seen from northwestern Montana lookout points, the black portions being invisible from the peak. It will be noted that in the visible portions conditions are decidedly favorable for the best method of location. The invisible portions should, of course, be covered from a second lookout, on the opposite side of the main valley, for which they in their turn would be favorably placed.

The method has seen but little actual service as yet, having been developed almost at the end of the past fire season on the Flathead National Forest, Montana. About six or seven locations were attempted, of which only two were of fires, the remainder being of any points which could be definitely determined on the ground. The points were from 5 to 12 miles from the lookout points (smoky atmospheric conditions preventing at the time any longer shots) and the maximum error detected was about 200 feet horizontally. It seems improbable that this degree of accuracy can be consistently maintained, but even much less precision would be reasonably satisfactory. The important chance of serious error is that a very small error in reading the dip, or in the map, may make the platted line of sight just miss the top of the correct ridge and strike the lower slopes of a second ridge, possibly several miles beyond, or *vice versa*. The only protection against this is to have the lookout supplement his instrumental readings with descriptive data dependent on his knowledge of the country. A statement that the fire is "On the north side of Canyon Creek" might prevent just such an error. Furthermore, the probability of such errors should be detected in doubtful cases when the course of the line of sight on the cross-section paper and map is traced, and appropriate action taken. The plan also fails to a considerable degree when smoke is observed rising from beyond a ridge and the fire itself is not directly visible. Any system is weak, however, in such a case, and the plan advocated should at least identify the ridge beyond which the smoke rises. It is, of course, important that the lookout man specify in his report whether or not he can see the source of the smoke.

The Abney hand-level is a fairly satisfactory instrument for such work. Its cost is, however, larger than necessary. The lookout clinometer need not be a hand instrument, more accurate results being obtainable with one which can be set on the lookout's map board. Figure 4 illustrates the construction of a simple clinometer designed for this purpose. It was constructed of sheet brass by a local tinsmith at a cost of $3.60, and while not of finished workmanship, proved quite satisfactory.

REVIEWS

The Rôle of Winter Temperatures in Determining the Distribution of Plants

An interesting article on this subject by Forrest Shreve, of the Desert Laboratory, Tucson, Arizona, appears in the *American Journal of Botany,* Vol. I, No. 4. Dr. Shreve points out the common error of phenologists in attempting to use the annual mean temperature or mean for the growing season as an index of the possibilities for plant growth. Such investigations have gone on the assumption that a degree in one part of the temperature scale is equivalent to a degree in another part of the scale. The well-known system of life zones proposed by Merriam not only is based upon this assumption, but takes no account of the temperature effects exerted in the frost season. It is considered by Dr. Shreve even more insufficient in that it ignores the important rôle of soil and atmospheric moisture.

Shreve takes the position that in the case of many plants it is the extreme winter temperature rather than the summer temperatures which determines their northward distribution. Few regions perhaps furnish such striking examples of this as does Arizona. The writer's observations in the higher altitudes of northern Arizona indicate that the failure of many of the common hardwood trees to live in that region is due not to summer conditions, but to winter conditions.

The region of Shreve's study covers the Santa Cruz Valley about Tucson and the slopes of the Santa Catalina Mountains. The altitude of Tucson is about 2,300 feet, and the highest peaks of the Santa Catalinas are somewhat over 9,000 feet. The lower limit of the juniper-oak type is placed at about 4,500 feet, and that of the pine forest at about 6,500 feet. The failure of forest trees to reach the desert is attributed mainly to the ratio between soil moisture and evaporation (low soil moisture and high evaporation) in the early summer.

In studies of temperature at various altitudes, cold-air drainage has been found to be an important factor. "The rapid nocturnal cooling of the desert soil—which is hastened by its dryness, its prevailing stony or sandy character, and its scant cover of vegetation—is responsible for a pronounced settling of cold air into the valleys and depressions, where it possesses a flow and a definite depth in close analogy to streams of

water." The minimum temperatures of the Santa Cruz Valley are always much below those of the Desert Laboratory, situated 335 feet above the valley, but only half a mile from its edge. The difference is greatest on clear, still nights during dry periods. At such times the valley temperature has been as much as 31° F. below that of the laboratory. On cloudy nights, after heavy rains, the temperatures of the two places have approached within 2° F., that of the valley being the lower. A similar relation has been found to exist between an open park and the adjoining timbered area at the Fort Valley Experiment Station.[1] In the latter case the park or valley was only about 50 feet below the surrounding timbered region. Although, in this instance, drainage from near-by mountains was recognized, the influence of the forest in checking nocturnal radiation and even in obstructing cold-air drainage was considered important. The following observations by Dr. Shreve throw additional light on the problem:

"In Soldier Canyon, at an elevation of 5,000 feet, in the Santa Catalina Mountains, the temperature of the floor of the canyon has been observed to be 8° below that of the slope of the canyon 100 feet above the floor. In Bear Canyon, at 6,000 feet elevation, in the same range, the minimum in the floor of the canyon has been observed 7° lower than the minimum of the rim of the canyon 1,000 feet above. Observations 100 feet above the floor would probably have revealed an even greater difference. The walls of both these canyons are clothed with open stands of desert and chaparral plants, the latter canyon having extremely rocky walls. In Marshall Gulch, at 7,725 feet elevation, in the Santa Catalina Mountains, the minimum temperatures are identical in the bottom of the gulch and on its rim, 275 feet above. The walls of this gulch, or canyon, are heavily covered with forests of pine, spruce, and fir. The drainage areas of the three mountain canyons are, in each case, much smaller than that of the Santa Cruz River.

"Our knowledge of the conditions which make cold-air drainage possible in the desert leads us to anticipate that it would be less well marked or even absent at the heavily forest altitudes of the desert mountain ranges. The diurnal heating of the soil and other surfaces is not so great in the forest, and the nocturnal radiation is retarded not only by the forest cover, but by the surface litter of the soil and by the greater humus content of moisture of the soil.

"The absolute minimum temperatures of the winter of 1912-1913 at several mountain stations showed that there was a successive fall of minimum from 17° at the Desert Laboratory (2,663 feet) to 13° at 4,000 feet, and —6° at 6,000 feet. There was then a rise of minimum to .5° at 7,000 feet, the first station in the forest, and a fall of —2° at 7,725 feet. Similar figures were secured in the winter of 1911-1912, showing the lowest absolute minimum for the mountain to occur not at the highest

[1] A Meteorological Study of Parks and Timbered Areas. G. A. Pearson, Monthly Weather Review, Vol. 41, pp. 1615-29.

station, but at the highest station below the forested elevations. The absolute minimum in the heavy timber at Marshall Gulch was 4° higher than it was 1,700 feet below in an open stand of manzanitas and oaks, a phenomenon in which cold-air drainage was not concerned, since the higher station was in the timber and the lower on a ridge.

"The strongly defined character of the cold-air drainage of the Santa Cruz Valley can be appreciated from the fact that the absolute minimum recorded in the valley was 1°, only three degrees higher than the absolute minimum 5,400 feet above in the forested region of the Santa Catalina Mountains."

The average fall in temperature for a large number of mountains in various latitudes is given as 3.46° per 1,000 feet. The gradient in the Santa Catalina Mountains was found to be 5.2° for each 1,000 feet, or more than 1 degree higher than the highest gradient previously recorded. The gradient derived from absolute winter minimums of the Desert Laboratory and of ridge stations at 4,000 and 6,000 feet (below the pine forest) is 6.6° per 1,000 feet, while above the commencement of timber it is only 2.5° per 1,000 feet.

"The streams of cold air from the mountain canyons are shallow, never exceeding 75 feet in depth and often being less than 50 feet. Below elevations of 6,000 feet, by virtue of these streams, the minimum temperature conditions of canyons and other topographic depressions are equivalent to those of ridges and slopes which lie about 2,000 feet higher. The vertical limits of a large number of species have been found to differ by this amount as determined for canyons and for ridges and slopes."

Studies of the vertical distribution of a number of plants throughout Arizona by Dr. Shreve indicate that the greatest number of consecutive hours of freezing temperature is the factor most closely corresponding, in the distribution, with the limitation of the species concerned.

"Experiments performed[2] with succulent plants native to various altitudes in southern Arizona indicated that the number of hours that they are exposed to temperatures below freezing determines their death, without regard to the absolute minimum reached during the freezing period (although minima below 18° F. were not used). The succulents which have the lowest vertical limit are unable to resist freezing over 19 to 22 hours in duration, while the species of higher and higher limits are progressively able to withstand longer and longer periods of freezing, up to 66 hours. With the limited hardiness of the Arizona species of cacti may be compared the behavior of *Opuntia missouriensis,* which withstood 375 consecutive hours of freezing temperature in the winter of 1910-1911, at Havre, Montana, near the northernmost limit of the succulent type of plant."

G. A. Pearson.

Albuquerque, N. Mex.

[2] Shreve, Forrest. The Influence of Low Temperatures on the Distribution of the Giant Cactus. The Plant World, 14: 136-146, 1911.

The Artificial Production of Vigorous Trees [1]

American foresters will be greatly interested in an investigation on "The Artificial Production of Vigorous Trees," conducted by Prof. Augustine Henry, of the Department of Agriculture and Technical Instruction for Ireland. Professor Henry is a pioneer in this work, having suggested the use of artificial first crosses in the production of timber prior to the work of Professors East and Hayes, who advocated the practical use of heterozygosis in the production of timber.

In "The Artificial Production of Vigorous Trees" the author outlines the procedure and difficulties involved in producing valuable forest-tree hybrids and encourages similar investigations along commercial lines.

In producing vigorous trees artificially the author makes use of the increased vigor which accompanies the crossing of naturally self-fertilized species. This first cross is found to be usually of exceptional vigor and more vigorous than either parent. When the first cross, however, is reproduced by seed, the second generation consists of classes of individuals which differ from each other and from their parents, in conformity with Mendel's law. They do not, therefore, come true to seed. It is necessary to propagate such trees asexually by cuttings or layers, as is easily done in case of the poplars and willows. Propagation is also accomplished by grafting, and for this purpose the seedlings of one of the parents are preferred.

Professor Henry observes that the degree of relationship existing between the individuals which are crossed is an important consideration in selecting parents for experimental work in hybridization. In order that the investigator may thoroughly understand such fundamental relationships, the terms "species," "variety," "race," "sport," and "hybrid" are given careful consideration. The discussion here would be helpful to many taxonomists, who too often evince a tendency to relegate species to a subordinate rank or to elevate varieties to a specific position, apparently without the slightest indication that they have experimentally proven or have concrete evidence of the status of the plant in question.

The author notes that increased vigor is found not only in the hybridization of distinct and unrelated species, but that the crossing of different races of a single species has been observed to be accompanied by some increase in vigor. This phenomenon might be turned to practical account in planting and reforestation work here. Many of the trees of

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[1] By Augustine Henry, M. A., F. L. S., Professor of Forestry, Department of Agriculture and Technical Instruction for Ireland. Reprinted from the Department's Journal, Vol. XV, No. 1.

North America are distributed over vast expanses of territory and have become segregated into more or less distinct races. Douglas fir (*Pseudotsuga taxifolia*), Lodgepole pine (*Pinus contorta*), and particularly western yellow pine (*Pinus ponderosa*), are examples. By the hybridization of two differing races or forms of the same species it might be possible to produce a new Douglas fir, a new lodgepole pine, or a new yellow pine. Such an experiment might even be attempted in our reforestation work without any great expenditure of effort or funds by introducing into one stand individuals of another race. Pollination would be effected by the wind and seedlings of increased vigor produced.

In Europe a number of unique and valuable trees are considered as having arisen in this way by the accidental hybridization of European and North American species which were growing in the same locality. The black Italian poplar (*Populus serotina*), for example, is held to be a hybrid of the American *Populus deltoides* and the European *Populus nigra.* This hybrid is of much more rapid growth than either parent and has replaced the European species in cultivation in England and in many localities on the continent. The "Norway poplar," now being planted extensively here in the United States, is considered by Professor Henry as either identical with this black Italian poplar or as another hybrid of similar origin.

The London plane (*Platanus acerifolia*), as in the case of the poplar mentioned, has characteristics intermediate between American and European species and has not been observed growing in a natural state. This hybrid, on account of its vigor and its resistance to drought, has become a favorite tree for planting, both in Europe and in the United States. Other remarkable hybrids, apparently of purely accidental origin and of economic value, have been acquired by the hybridization of allied European species. The common lime (*Tilia vulgaris*), the Huntingdon elm (*Ulmus vegeta*), and the cricket-bat willow (*Salix cœrulea*) are specimens exhibiting marked increase of vigor.

The method used in the artificial production of vigorous trees is of interest. Both male and female flowers are protected against stray pollen by bags of stiff paper, which are closed around the twig by a thin wire, which is drawn tightly to prevent movement of the bag on the branch. The twig selected for bagging should have as many flowers as possible. This work is not done in wet weather, as the flowers become infected by fungi. The male flowers are covered about a week before the antlers dehisce. The female flowers are covered two weeks before the stigmas become receptive and for a week succeeding pollination. In the case of monœcious and diœcious trees self-pollination is readily prevented, but

in the case of perfect flowers the antlers of the mother flower must be removed by means of needle-pointed forceps. This operation, which must be performed before the antlers dehisce, is a delicate one on account of the fact that the pistil dies if the style, stigma, or even the ovary is touched. Pollen is collected by cutting off flowering twigs and placing them on white paper in a dry place for a day or two. In crossing two species which flower at different times, the pollen may be preserved for days if kept in a small glass tube plugged with cotton wool. Pollen is applied to the stigma by means of a camel's-hair brush. A minute quantity is sufficient for each stigma, which is only receptive for a short period, indicated by the presence of a sugary solution or by a change to a brighter hue. The author notes that pollen grains may not germinate on the stigma of another species and yet be capable of fertilizing it if germination is induced by the transference of a drop of the substance secreted by the stigma of the pollen-bearing species to the stigma of the flower to be fertilized.

Formidable difficulties were encountered by Professor Henry. Delicate manipulations of hybridization on tall trees are difficult to perform and often attended by considerable personal risk. The occurrence of late spring frosts damaged flowers after fertilization, but the results obtained by the author not only demonstrate conclusively that new trees can be artificially produced, but also that the conduct of similar work along commercial lines, and especially in southerly stations, where lofty greenhouses are not required, should be undertaken by enterprising firms.

Foresters are liable to feel that their profession deals only with wild plants which are scarcely modified by cultivation. With the vast acreage of virgin timber at their disposal, they are very likely to relegate matters pertaining to hybridization to the horticulturist. Accustomed to deal with native trees growing under natural conditions, we have scarcely considered the importance of these investigations. Trees are long-lived plants, and it is often necessary to wait a number of years for them to bear fruit. All of these factors impel the American forester to eschew such problems, especially as his supply of natural timber is anything but depleted.

In Europe, however, foresters recognize that even the planted timber which has been so carefully grown is entirely inadequate for their needs, and that with the depletion of exotic forests their only hope for the perpetuation of the timber supply will lie in their ability to produce rapidly growing trees. The enormous destruction of European forests incident to the extensive military operations of the present war will increase the foresters' anxiety to propagate vigorous trees. The species supplying

merchantable lumber in the briefest time will be most desired, and the artificial production of a forest tree which will exceed in vigor any natural species would be an achievement of the greatest economic importance.

W. H. Lamb.

Forest Service,
Washington, D. C.

Natural and Artificial Regeneration in the Forests of Northern Sweden [1]

Even up to a few decades ago, lumbering was carried on in the extensive forests of northern Sweden without any regard to the regeneration of the forest. In 1860 the government issued instructions that cutting should be carried on under the selection system, with a return to the cut-over areas at the end of 60 years. The reproduction which started after this selection cutting was rarely satisfactory. This led to the issuance of new instructions in 1902, by which certain portions of the cut-over areas were to be managed successively as reproduction areas—that is, with the special purpose of obtaining natural reproduction. The 1902 regulations are still in force, but they have not brought adequate results. This lack of reproduction is mainly to be accounted for as follows:

1. The forest administration is too extensive, and hence but little attention can be given to local regeneration areas.

2. The lack of definite knowledge on the relative merits of different silvicultural systems under a given set of climatic and soil conditions. The Forest Experiment Station has inaugurated extensive experiments in an effort to supply this knowledge. Conclusive results from these experiments cannot be gained for some time. In the meantime the Experiment Station has attempted to arrive at explanations for the results on older experimental areas established in several reviews of northern Sweden in 1880 and 1890. Five cutting areas, approximately 175 acres each, were established. Four of these were cut between 1895 and 1897, and were located in a pine forest with a floor thickly covered with moss and situated on a boulder-strewn moraine. A brief statement of the character of the cuttings on these four areas and the reproduction existing on them *in 1912* follows:

Area I.—All older trees, with exception of 1-3 per acre, were cut. All groups of young trees were left.

Reproduction: 1,830 pine seedlings per acre, ranging from 0 to 13 feet in height.

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[1] Review of article by Edward Wibeck in Report of the Forest Experiment Station of Sweden, Vol. 10, 1913.

Area II.—Largest and most merchantable trees cut. An open stand of small but old pines, numbering about 40 per acre, remained.

Reproduction: No noteworthy reproduction; only here and there remaining groups of trees and saplings in the openings showed evidence of somewhat increased growth.

Area III.—This area was entirely clear-cut. The brush, together with the remaining undergrowth, was then burnt.

Reproduction: Approximately 1,800 seedlings per acre, ranging from 0 to 11 feet in height.

Area IV.—Cut clear, but not burned over; on the contrary, the brush and all the felled, unmerchantable material was allowed to lie in place. The area of this clear-cutting was about 50 acres.

Reproduction: Came in much slower than on the three preceding areas, but it was much denser—3,410 seedlings per acre.

Area V.—The fifth cutting area lies in a pure pine forest, on an alluvial sand, and was cut in 1885, ten years earlier than the other four areas. The clear-cutting was, however, only five acres in extent. The brush was allowed to lie in place, just as in Area IV.

Reproduction: 4,500 pine seedlings per acre, from 0 to 6 feet in height.

These experimental areas show decisively that in northern Sweden the best method of reproducing stands, in pine forest still producing seed, is by clear-cutting. In selection stands Nature rarely supplies satisfactory reproduction; even a very light overhead shading suffices to retard reproduction.

Artificial regeneration is practiced only to a small extent in northern Sweden today, primarily because of the invariable failure which characterized earlier attempts. Recent experiments indicate that these failures are to a large extent due to the fact that seed of native origin was *not* used. Experiments show that transplants from seed of native origin are far superior to those which originated from seed obtained in other parts of the peninsula.

A. J. Jaenicke.

Fort Valley Experiment Station,
Flagstaff, Ariz.

COMMITTEE ON TERMINOLOGY

The President has appointed the following members to serve on the Committee on Terminology during the present calendar year:

Collating Subcommittee

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C. D. Howe
Clyde Leavitt
W. N. Millar
Ellwood Wilson
J. H. White

Subsection on Utilization and Protection

R. C. Bryant, Chairman
B. P. Kirkland
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T. S. Woolsey, Jr.

Subsection on Valuation, Administration, and General Terms

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Subsection on Silviculture, Silvics, and Forest Description

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Subsection on Organization, Mensuration, and Management

A. B. Recknagel, Chairman
W. B. Barrows
W. M. Drake
P. S. Lovejoy
D. T. Mason
T. S. Woolsey, Jr.

The committee made substantial progress during the past year and expects to finish the work assigned to it during the coming year.

In order to facilitate the work of the committee and make the revision of our forest terminology as thorough as possible, members of the Society, as well as all others who are interested in this work, are requested to send at an early date new terms and suggestions to the chairmen of the subcommittees.

ERRATA

By some inadvertence on the part of the proof-reader several regrettable typographical errors occurred in John D. Guthrie's article, "Land Classification Rules for an Arizona Forest," which appeared in the January issue (Vol. X, No. 1) of the Proceedings.

On pages 23 and 24 the letter "M" for thousand feet was omitted, making the total stand of sawtimber on the Apache as only two million instead of two billion; also, in the same paragraph, in speaking of possible sales for 300 million feet and one billion feet respectively, the article gives it as 300 thousand feet and one million feet respectively. The same omission is made on the top of page 24, where the annual consumption of mining timbers is given as 20 thousand feet when it should be 20 million.

Proceedings
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CONTENTS

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The Proceedings of the Society of American Foresters appears quarterly—in January, April, July, and October. It contains papers delivered before the Society at its regular meetings, and original contributions by both members and non-members of the Society.

Papers that have already appeared elsewhere will not be accepted for publication. Simultaneous publication in another journal will not be agreed to.

Manuscripts may be sent to any member of the Editorial Board and should be clearly typewritten and in suitable form for printing without essential changes. Footnote references should be complete, including year of publication.

The Editors reserve the privilege of returning to the author for revision approved manuscripts and illustrations which are not in proper finished form for the printer, or, if the author so desires, the Editors will have the manuscripts and drawings prepared and charge the author the cost of this work.

Illustrations will be used only when absolutely necessary and will be confined largely to text figures or diagrams of simple character. The Editors, at their discretion, may call upon an author to defray the cost of his illustrations.

Since the membership of the Society is scattered throughout the United States and the nature of the field work of its members takes them often to remote and inaccessible places, in order to secure prompt publication no proof will be sent to authors unless requested. They are urged, therefore, to submit their manuscripts in final form and the Editors will exercise care in seeing that copy is followed.

The author receives only one free copy of the number containing his contribution. Reprints, however, can be secured at cost.

As an author may not see proof, his request for reprints should reach the Editors before his paper goes to press and should preferably be attached to the first page of his manuscript.

Missing numbers will be replaced without charge, provided claim is made within thirty days after date of the following issue.

Joseph A. Holmes

July 30, 1915.

The Society of American Foresters, desiring to record its deep sense of loss in the recent death of Professor Joseph A. Holmes, has adopted the following minute:

By the departure of Professor Joseph A. Holmes, Director of the United States Bureau of Mines, and an honorary member of the Society of American Foresters, the cause of the forest in America has lost a vigorous and most effective supporter. For more than twenty years Professor Holmes has been a strong, ready, and active friend of forestry. He originated the plan for an Appalachian National Forest, and took a leading part in securing the act of Congress which adopted it as a part of the National Forest policy. In the early struggles of the United States Forest Service his help was of peculiar and more than once of indispensable value.

Professor Holmes's influence was always larger than the official place he held. As State Geologist of North Carolina, he exerted a pressure for conservation which was nation wide in its extent. His influence was greatly increased when, as the creator, organizer, and first Director of the United States Bureau of Mines, he came to live in Washington. His high and sound scientific attainments, his wide knowledge of men and affairs, his remarkable energy and initiative, and his unsurpassed power of work, all were used with the finest generosity to advance the common welfare through the wise use of the natural resources. At length the strain of incessant useful action in the public service wore out his physical resistance. As truly as any soldier, he gave his life for his country. We honor him as we recognize our debt.

Proceedings
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Vol. X | JULY 1915 | No. 3

WORKING PLANS: PAST HISTORY, PRESENT SITUATION, AND FUTURE DEVELOPMENT

BY BARRINGTON MOORE

Contributed

CONTENTS

PURPOSE

Progress in working plans, as in everything else, depends not only upon a mastery of technique, but upon an understanding of the situation—past, present, and future. With technique, but without an understanding of the situation, the forester is helpless. Most of the working-plan literature in this country has dealt chiefly with the technique, as is proper it should. It is time now to look at the situation. More will be

gained if every one who has ideas on the subject will come forward; the more points of view presented the better.

If this paper deals primarily with government working plans, it is because the government has until recently been the sole timberland owner in this activity. To the majority of private owners the management of lands for the permanent production of timber has been rendered undesirable, if not actually impossible, by financial and other conditions beyond their immediate control. There is, however, a beginning of slow but normal and healthy development of working plans among private owners, who must hold their lands permanently and who have an incentive to grow timber either for their own use or as a secondary source of revenue.

POINT OF VIEW

A clear and broad point of view is essential both to a proper understanding of the situation, past and present, and to sound progress in the future. It is safe to say that to the point of view is attributable a large proportion of the failure and success in working plans as in all other activities. For this reason it is important to know at the outset the point of view which has guided this paper.

The keynote of this point of view is that working plans are subject to the laws of growth instead of being a more or less fixed institution. This is merely in accordance with the present-day teachings in all lines of science and history, and is so simple as to sound almost like a truism. Yet it has not, as far as we know, been stated before, and certainly has not, except recently, in a few instances, been acted upon. If it had been, the history of working plans would show a gradual evolution instead of, as it does, a series of attempts to establish fully developed working plans.

Underlying this conception of growth in working plans are two fundamental principles which, though but dimly realized and never expressed, have none the less surely controlled the progress of plans.

The first principle is that *before the development of a plan can even begin, there must be a demand for the resource or for the performance of the work with which the plan is to deal.*[1] Where such a demand is lacking or insufficient to create the necessary incentive, plans can be made but will lie unused. This has been the case with timber plans. Plan after plan has been made for National Forest timber, where the demand for timber was too small to call for a plan, where good silviculture, together with utilization data and rough timber estimates, would suffice.

[1] The first to clearly see and act upon this principle was J. T. Jardine, in charge of the collection of grazing data and of grazing plans.

Hence these plans, except where they contained new silviculture, utilization data, and estimates, have not been used. The concentration of first attention on timber plans was, however, natural, in that working plans were considered an important part of forestry, and the only kind of working plans known were timber plans. Furthermore, over-optimistic forecasts of regional development foresaw a heavy demand for timber in the immediate future, a demand which either did not materialize or, if it did, was generally met in a way entirely at variance with the ideas of the preceding few years.

On the other hand, there has always been a strong demand for fire protection; among all kinds of forest activity this comes first. Hence, while timber plans were being pushed vigorously, with but limited success, fire plans sprang into existence almost of themselves.

The second principle is that, even when the demand is sufficient to call for a plan, *sound plans must be the result of normal development.* Unless a plan is developed normally it will not fit the situation and will consequently remain a dead letter. And normal development requires time; it cannot occur suddenly. Hence effective plans cannot be drawn up all at once out of a clear sky, so to speak. The local force must have a few years to study the subject of working plans to get into sympathy with the aims of plans, and to find out just what form of plan will be most effective and what should be included. With fire plans this preliminary period has generally been passed through unconsciously in the actual work of building up the protective system from season to season. In other lines also the actual work sometimes serves more or less the purpose of this preliminary period. In the drawing up of the plan after this preliminary period it is often necessary to try a number of times before just the right material and the most suitable form are secured. Experimentation is as necessary in working plans as in other branches of forestry. The development of effective plans, not necessarily final plans, is therefore a matter of years, not of one or two seasons, as has hitherto been supposed. The number of years will vary with the line of work and with the conditions: fire plans can be made effective, as effective as the protective facilities permit, in only a few years; grazing plans will probably take longer, and timber plans longest of all.

The idea to bear in mind, then, is that normal development is bound to be slow, and that therefore we must not be discouraged by lack of immediate results, provided the development is along sound lines. It is earnestly hoped that the foregoing point of view and principles may aid in clarifying the situation and in directing future progress, because working plans in this country are still only in the earliest stages of their development.

PAST HISTORY

General

An understanding of past ideas, conditions, and events is essential to success in the future. Without such an understanding mistakes are liable to be repeated.

In tracing the development of working plans, more will be learned from a study of the leading ideas and conditions prevalent at different stages than by a discussion of the plans themselves. The individual plans will be considered only in so far as they illustrate the working out of ideas in relation to existing conditions.

For convenience and clearness the past history of working plans will be treated under two broad headings, on the basis of the main factors surrounding their development, namely: (1) Bureau of Forestry working plans for State and private lands. Only one plan was for State lands, for New York, and was made before the office became a Bureau, while it was still the Division of Forestry; (2) the plans made by the Forest Service for the National Forests between 1905 and 1911.

Bureau of Forestry Plans for Private Lands

All those who have studied working plans are more or less familiar with the old Bureau of Forestry plans for private holdings and with the failure of all except one of these plans. The writer has just gone over six of these in the light of the more recent work of the Forest Service, in order to see just what were the causes for failure, and whether they contain any lesson of importance which might be overlooked.

Our understanding of this old work will be greater if we stop to consider that it comes in the period of practically pure European ideas, before there was any fundamental knowledge of American conditions or of how to adapt forestry practice to these conditions. Furthermore, it sometimes happened that the form rather than the spirit of the European idea was all that reached this country. Hence forestry meant certain woods operations which were practiced in Europe; to introduce forestry into this country meant to introduce similar operations. There was at first little idea, except among a few unusual men like Austin Cary, of beginning gradually with simple operations, such as saving waste in the woods, and other steps which would appeal directly to the lumbermen. European ideals had to be adhered to or the work was not forestry.

Under the conditions prevailing in the southern yellow-pine region, in which most of the plans were made, forestry as understood at that time was an utter impossibility. Fire protection was impossible without the

expenditure of enormous sums and the arousing of bitter antagonism among local inhabitants, who considered the annual firing of the forests to be indispensable for the pasturage of their stock and to be their right, just as much as plowing their fields to plant corn. If effective fire protection had been enforced and stock excluded, the owner, aside from the cost of these measures, would have run the risk of having his mill burned up or of being subjected to other forms of reprisal. Yet absolute fire protection over the entire area was made a *sine qua non* of all these working plans. There was no mention of a modified form of protection which might have stood a chance of being successful, such, for example, as confining protection to the regeneration areas until the trees became large enough to withstand fire, followed by a light burning in the wet season to minimize the danger after the removal of the protection. Another unfavorable condition was the slow rate of growth in yellow pine. This made the returns on the investment, figuring the prevailing stumpage prices, so low that to bring the interest rate up to even 5 per cent the assumption of an increase in stumpage to more than double the prevailing rate was required. Such speculation in a 5 per cent investment, when gilt-edge securities would yield as much and more, seems to us now absurd enough even, aside from the virtual certainty of loss by fire. These points must have been obvious to the owners for whom the plans were made; in fact so obvious that it is unpleasant even now to picture to ourselves what those owners must have thought of forestry.

Since the men who drew up these plans have shown marked ability in later work along many lines of forest activity, the tendency has been to pass over this early work as belonging to the mistakes inevitable at the beginning of any new profession. This view is correct as far as it goes, but merely touches the surface; for a fuller understanding we must go deeper.

The failure of these plans was, as we have shown, due to prevailing conditions. Knowledge of the reasons why these conditions were overlooked will help to explain many early mistakes, and will also furnish a useful point of view for present work not only in working plans but also along other lines. Four causes more or less related and interacting help to explain this neglect of conditions.

(1) The first cause was a keen interest in the rights of future generations. For the spread of this wholesome point of view the country owes a great debt to these foresters. Yet, like any new idea, it was carried too far and the present generation was ignored. Where present and future interests conflicted preference was given to the future. The conception of caring for the future without sacrificing the present did not come until later.

(2) The second cause was a lack of understanding and lack of desire to understand the position of the lumberman. Coupled with this point of view was the vague idea that lumbering was enormously profitable; that the timber had been bought for next to nothing and sold at fabulous profits. The vicissitudes and losses in the lumber business escaped attention. It was but natural therefore that foresters with these ideas should feel bitterly toward the lumbermen for destroying the forest, and should fail to see that the lumbermen were not destroying the forest wantonly but because they could not do otherwise without financial loss. Under these circumstances it was inevitable that remedies not only futile but disastrous to the lumbermen should be proposed.

(3) The third cause is closely connected with the second, namely, the lack of business training in foresters of that day. This was to be expected, in that ideas were mainly derived from Europe, where business training is of minor importance in forestry. Furthermore, it is commendable that in the very beginning the technical rather than the business ideal was set up. This situation led to the long drawn out controversy between theoretical (or technical) and practical (or business) training in forest schools. Happily, business knowledge has in general been given its proper place without sacrificing the technical ideal.

(4) The fourth and perhaps greatest cause of overlooking conditions is one which in other directions proved the strongest asset of the forestry movement, namely, its enthusiasm.

Foresters felt that they possessed new and vital ideas which were of great importance to the future welfare of the country and, like all whole-hearted workers in a new movement, they wanted to put these ideas into force without delay. They felt that their method of handling the forests was best in the long run, and that therefore any opposition must be fought vigorously.

The course of this enthusiasm can easily be traced. Filled with a genuine love of the forest, as all true foresters are, these men felt that the good of the forest should come first. Delay in the application of forestry principles meant just so much more forest destroyed and land rendered unproductive. Hence the conception of a slow but safe development of forestry practice, if it ever occurred to these men, must have been instantly dismissed. Furthermore, forestry besides being essential in justice to future generations would, it was thought, yield handsome profits, as it did wherever else it was applied. Under this enthusiasm obstacles were overlooked or waved aside. Although this spirit was admirable in its effect on public sentiment, as well as in raising the position of the profession of forestry in the country, yet there is no denying

that when carried to extremes its effect upon the work was injurious. The forestry idea so far outran its possibilities for accomplishment that only now after ten years are the accomplishments beginning to catch up. The one exception to the list of failures is the plan for the University of the South at Sewanee, Tennessee,[2] and it is significant that this work bears the modest title "Conservative Lumbering" rather than the more ambitious one of "Working Plan."

The conditions at the University of the South were far more favorable than elsewhere, both with regard to the ownership and to the forest itself. The University, although needing revenue from its forests, was in a better position to practice forestry and more disposed to do so. The forest itself was of hardwoods which could be injured, but not completely destroyed, by fire and grazing. These conditions should not, however, be allowed to rob the maker or makers of the plan of due credit. This plan, though one of the earliest, shows more insight into the wishes of the owner and the needs of the situation than any other plan for private owners. Here the forest needs an outlay of money, but at the same time the owners need revenue from it. The owners are given a revenue, even though some points of perfect silviculture may be sacrificed, and at the same time the forest is improved. For example, the extraction of timber is easy on the plateau, but difficult in the coves below the plateau. Therefore only sawlogs are cut from the coves, but sawlogs, ties, and firewood are taken on the plateau. The forest was admittedly in bad condition, and the first thing to do was to improve it. Hence improvement cuttings alone were considered, regardless of future yields. In this connection it is interesting to note that the same policy is followed by foresters in British India. In damaged forests attention is centered on improvement cuttings, and yield is altogether ignored until the forest has been brought into proper shape.

It is hardly to be expected that now, about twelve years after the making of the plan, the detailed provisions should still hold; under even the most intensive management revision would be necessary. Yet, in spite of difficulties with fire, the cutting is still done conservatively and with a view to reproduction.[3] It may safely be said therefore that the purpose of the plan has in the main been successful. The point worth remembering in this connection is that this plan modestly attempted but little where only a little can be done, and succeeded in what it attempted. If

[2] "Conservative Lumbering at Sewanee, Tennessee," by John Foley. U. S. Dept. Agr., Bur. of Forestry, Bul. 39, 1903.

[3] Statement of the Chancellor of the University of the South under date of Feb. 15, 1915.

more had been attempted and a more detailed plan drawn up, it is probable that nothing would have been accomplished.

Had the attitude which governed the working plan for the University of the South prevailed, more substantial progress would probably have been made. But it still remains an open question as to whether or not forestry would have secured the popular support so quickly if it had started out with firmer but slower steps. However, now that the position has been secured, there can be no doubt but that the aim should be to consolidate it by building the foundation which was originally omitted, but which will soon be necessary if the position is to be maintained.

Forest Service Plans Made for the National Forests Between 1905 and 1911

The characteristic feature of this period, if one feature alone were to be selected, would be rapid changes caused by earnest striving for progress. The changes in ideas as to what should constitute a plan were so rapid that plans which were started, according to the latest conceptions, were so out of date by the time they were submitted to the district and Washington offices that they had to be sent back to be rewritten. During this period no working plans were approved by the Forester and put in force.

The period represents only the first stages of experimentation in the making of plans, all the stages of which have not even yet been passed through. But the experimentation was wholly unconscious. Every man making a plan sincerely felt that he was drawing up the provisions which should and would guide in handling the area with which he was dealing. It was not until the plan had been criticised, cut up, revised, and finally put in the files for use in drawing up a plan along entirely different lines that the author began to understand that his work was merely a step in the development of working plans, not a plan in itself.

Conditions peculiar to America make this experimentation a necessary part of the normal growth of plans. These conditions fall under two main heads: (1) The large size of the areas to be managed. This controls the character of the feasible operations, preventing altogether much that on smaller areas is considered essential, and modifying the rest. (2) Economic conditions, in particular the undeveloped nature of much of the territory containing the National Forests, combined with the rapid but by no means uniform development of this territory. Some places show more rapid growth than others, due to a number of interacting factors which need not be considered here; and periods of rapid progress are interrupted by periods of comparative quiet. These conditions are normal in any new and actively growing region, but, owing to the de-

pendence of forest management upon economic conditions, affect forest management rather more seriously than has generally been realized. The uncertainty attendant upon these conditions must inevitably be reflected in the handling of the forests. Methods of management based on calculations of requirements for only a few years to come are liable to be badly disturbed by radical changes in these requirements. It has therefore been due to conditions, as well as to development in ideas, that plans have required revision almost as soon as they had been written.

In spite of these conditions, the main idea of European plans, regulation of the cut, persisted to a great extent in American plans and gave rise to considerable trouble. The Indian idea of including forest description, or silvics, and silviculture was also introduced in some places; but the conception of a working plan as consisting solely of regulation of the cut was, however, so strong that among many foresters the terms working plan and regulation of cut were synonymous. Where sustained yield was for the time impossible, and this was and still is the case on many National Forests, plans were often considered impossible.

This should not be taken as condemnation of regulation of the cut in working plans; regulation is extremely desirable where feasible, and must eventually be applied universally. Plans can and should exist without detailed hard and fast provisions for sustained yield until such time as sustained yield becomes possible. At the same time the best available approximation of the yield of the forest should be given, even though it need not be adhered to, so that it will be possible to tell roughly the amount of the undercut or overcut.

There is another important condition which must be realized before the development of government working plans or forest plans can be understood. This is the relation between the plan and the management of the forest. The actual work of handling the forest received first attention, as it quite properly should, and the plan followed in the wake of this work rather than leading it. Ordinarily where forestry has long been practiced the reverse is true; the plan comes first and guides the management. But when forestry is introduced bodily, rather than as a result of growth, as in Europe, the first thing to do is to put the forest under administration, so that it can be protected from fire and trespass, and so that its resources, both in timber and grazing, can be utilized with a minimum of waste and destruction. With an enormous area to handle and a small force at its disposal, it was but natural that almost all of the energies of the Forest Service had to be turned to the immediate problems of administration. Protection against fire was the first and foremost need, calling for trails, telephone lines, ranger cabins, etc., in

hitherto inaccessible mountains. Grazing lands must be utilized and timber sold. To do this without injuring the forage crop or destroying the forest required adequate supervision. Although the work on which the growth of plans depends was being done, nobody had time to think of writing plans.

The only activity considered in connection with plans up to about 1910 was timber management or silviculture. This was probably the natural result of long established custom in forestry-practicing countries, where working plans mean timber plans and where plans for other lines of activity, such as grazing, have never been made, because these other activities either do not exist or are of minor importance. At this time the supervisor's annual plans for grazing, improvements, expenditures, etc., were considered entirely apart from working plans. Hence in speaking of these early plans we must remember that we are dealing almost entirely with timber plans, not with plans for all lines of forest activity.

One of the earliest plans was that for part of the Henry's Lake, now Targhee National Forest. It was based on a map and estimates which were secured primarily for the purpose of the plan, and is probably the last case of mapping and estimating chiefly for a plan. A few years later the plan was made a coördinate object with securing an inventory of the timber for use in sales; now the plan has dropped out altogether as an object, and maps and estimates are made only where a sale is in immediate prospect.

The Henry's Lake or Targhee plan was followed, after the creation of the six districts, by a number of other plans for the Forests of District 4, which includes southern Idaho, part of western Wyoming, Utah, and most of Nevada. These plans were made as a result of timber reconnaissances, generally covering only parts of the Forest and generally by rather rough methods. Most of these plans are, however, considering the difficulties under which the mapping and estimating were done—creditable pieces of work. Some of them give very good general information on the region, including topography, climate, industrial development, etc.; good silvical descriptions of the important forest types; the methods of silviculture which the available data indicate, and rough approximations of the annual yield—all this in addition to the maps and timber estimates. Although the data were rough and the results were more in the nature of reconnaissance reports than even preliminary plans, yet substantial progress was made in the right direction.

In several of these earlier District 4 plans the idea of including all lines of forest activity in a single Forest plan was well developed. The

final product of this period's work in District 4 was the plan for the Cache National Forest. This was intended as a model plan for the District, to assist and encourage all the other Forests in making plans. Although it was not immediately followed by similar plans on all Forests, yet it did serve to stimulate and spread ideas. It followed closely the instructions of the Forest Plans part of the Manual, issued November 1, 1911, giving separate plans for General Administration, for Silviculture (or Timber), for Grazing, for Permanent Improvements, and for Fire Protection. The data for each plan were necessarily scanty, and, as might be expected at this stage of development, some of the ways of handling the problems could have been improved. In spite of these unavoidable weaknesses, the plan as a whole was good, and unquestionably will increase the efficiency of all lines of work on the Cache.

The explanation of District 4's activity in working plans, particularly in timber plans, is to be found in the unusual importance of her Forests, both as wood producers and as conservers of water indispensable for irrigation, particularly in southern Idaho, Nevada, and Utah. Practically all of the plans, it will be noted, are for the sparsely timbered Forests, thus unconsciously following out the principle given above under "Point of View," that a demand for the resource must precede the making of a plan.

During this period (1905-1911), particularly after 1908, the district most active in working plans was District 3, Arizona and New Mexico, and also at that time Arkansas and Florida. This district pushed working plans with more vigor and enthusiasm than did any of the others and had the highest ambitions. Although there have been many failures, yet the work still continues vigorously.[4] The underlying cause of the interest in working plans in District 3 was similar to that in District 4, namely, the unusual value of the forests as producers of timber and conservers of irrigation water. The pressure was probably even greater in 3 than in 4, because these conditions apply to a larger proportion of the district. The only other district with comparable problems is 5, with its semi-arid southern California Forests; but here the arid Forests comprise such a small percentage of the district that the incentive for plans does not reach the district office.

The activity in District 3 at first took the form of wholesale mapping and estimating. The purpose was twofold: (1) To secure an inventory of the timber resources of the district for use in sales, the inventory con-

[4] See article by Joseph C. Kircher, "A Proposed Method of Preparing Working Plans for National Forests." Forestry Quarterly, Vol. XII, No. 2, pp. 145-157. 1914.

sisting of estimates of the timber by 40-acre blocks and detailed maps of the topography and forest types; (2) to secure data for working plans. It was thought at the time that ocular estimates by 40-acre blocks, when supplemented with descriptive notes on the reproduction, age, and condition of the timber, soil, and other points, would serve both purposes. The men, before being sent out, were given practice on sample 40-acre plots, and during the course of the day were supposed to check their judgment by occasional sample areas.

The method was started by a professional timber cruiser who was in charge of the field party on the Coconino in 1908. An accuracy of within 10 to 15 per cent of the actual stand was expected in the estimate, a degree of accuracy considered at least ample at that time, and which even now is believed to be as close as is feasible in all except the most valuable timber. In actual practice, however, the Coconino estimates were found to be about 25 per cent too low. When the method was used by untrained crews in succeeding years the errors were found to be even greater, ranging from 50 to 60 per cent low. The method always gives an underestimate, because every man, unless possessed of supreme self-confidence, will hesitate to throw his estimate up to the highest point which his judgment indicates, and will almost always through natural caution give the benefit of the doubt to the lower quantity. Unfortunately the errors of even a single individual are very difficult to correct in the final estimate, because they vary from day to day and even within a single day. However, it is probable that a fair idea of the lump estimate over a considerable area can be secured by the prevailing system of raising the entire estimate by a certain correction factor determined by accurate methods of check estimating; but the figures on single forties will still be wholly unreliable.

In mapping topography the Forest Service fortunately went beyond the cruiser's method of hachures and secured excellent contour maps. Systems of control had not yet been sufficiently perfected, but the errors in this direction are not great enough to injure the value of the maps as a whole, while the topographic detail is admittedly even better than that secured by the Geological Survey. The cost of these maps has been slight because the ground must be covered anyhow for the estimate and no material delay is caused by mapping topography at the same time.

Ideas concerning the data needed for working plans were rather hazy at the time this mapping and estimating was being done; and, even though the need for more detailed figures was dimly felt, the extra expense which these figures would have required stood in the way. Even as it was, the reconnaissance work was not really justified either by pro-

spective sales or by a genuine demand for working plans, though it was thought to be at the time.

Therefore, in basing working plans on the results of this reconnaissance a number of difficulties were encountered. In the general data called for under Part I of the outline then in force, an outline which covered all essential points, some of the headings, such as status of the land, topography, population, industrial development, etc., could easily be covered, whereas others, such as geology, soils, and climate, had to depend largely upon the training and ability of the man in charge. The forest description and silvical data were supposed to be secured by means of the descriptive notes of the estimators. Actually these notes were generally of such a perfunctory character as to be of little value; and furthermore, since they were by forties and sections, they were practically inaccessible without unwarranted effort until 1911, when they were assembled by watersheds instead of by sections. The upshot was that forest description and silvical data were left dependent upon the silvical interest and observational powers of the chief of party, a man already too busy trying to do the same work as each member of the party and the supervision of all members as well.

The development of silvicultural systems was in much the same position as the forest description and silvical data, only worse: in addition to depending upon the silvical interest and observation of the party chief, it depended also upon his experience and ability in marking timber. It must be remembered here that every party chief was under pressure for "results," and that "results" consisted largely of covering a maximum of area at a minimum of expense.

If the position of the silvical and silvicultural data be considered bad, that of the increment data must be thought well-nigh hopeless. The growth of individual trees was determined necessarily on cutting areas, independently of the mapping and estimating. These figures, reasonably accurate for the areas whence they were taken, were subject to error when applied to other areas. This error was, however, a comparatively small matter. The chief difficulty was that the method of estimating gave no stand table to which to apply the growth of individual trees. The only way of finding the increment with the available data was by determining the per cent of growth in volume for the individual tree (Graves' Mensuration, pp. 302-303) and applying this growth per cent to the entire volume of the area, as shown by the ocular estimates. Aside from the obvious errors involved in applying the growth per cent to rough estimates, there is the error involved in deciding upon the period which the growth per cent shall cover, a decision which in old trees must be to a

certain extent arbitrary, and the further error that the resulting increment is that of virgin stands, giving no idea of the increment to be secured under management.

With such inadequate data on increment and present volume an accurate determination of the yield was impossible. Yet calculations of the yield were made with this data, and were justified by the fact that some idea of the possibility of the forest, even though it be an extremely crude idea, is better than none. The aim was to make these limitations conservative and to use them merely as a sort of danger signal, at the approach of which it would be advisable to collect the data for a more accurate determination of the yield. Von Mantel's formula would have served the purpose, and was, strictly speaking, the only volume method which the data justified. Instead of this, or rather in addition to it, for the Mantel formula was always used as a check, the Austrian formula was employed. The reason was that with such crude data the yield had to depend to a certain extent on judgment. The Austrian formula was preferred because the latitude which it permitted in distributing the surplus of deficit growing stock allowed the introduction of just the necessary amount of judgment. Since it was realized that such work was merely a makeshift, the calculation was always carefully guarded by all possible manner of checks.

As soon as the inadequacy of the increment data was realized proposals were made for correcting the deficiency by special work. Nothing was done, however, because uncertainty as to the best method to employ made it unwise to incur the necessary expense until a method satisfactory to all should be devised.

Another disadvantage under which these early plans suffered was the feverish rush of the field work, which threw chiefs of party from one project to the next without allowing them time for so much as a report on their last project. This was injurious in two ways: First, it failed to secure the full value of the money expended in field work, because a great deal of valuable information which the chief of party may have collected not only on the timber, but on grazing, fire protection, and permanent improvement as well, can be made available only if he is given breathing space enough to sift it down and record it. Second, it often became necessary for the plan to be written up by a member of the district office staff, who not only had little first-hand information on the Forest in question, but also was crowded with urgent administrative duties.

It is small wonder, then, in view of all the foregoing circumstances, that the timber plans of District 3 were not a success. The wonder is

rather that so much was expected, and that some men's hopes ran so high that they sent several of these plans to Washington to be published as models for the education of the profession in general.

Nevertheless, the working plan's activity in District 3 was by no means wasted. It produced topographic maps which alone are worth almost the entire cost of the work; secondly, it gave an inventory of the timber which, though subject to error, can still be corrected and used; lastly, it gave much valuable experience in the making of plans, thus applying the necessary experimental stages through which all activities must pass before full efficiency can be attained.

During this period Districts 3 and 4 were the chief ones in which the district offices played a leading part in the development of working plans. This was but natural, since in none of the other districts did such large proportions of the area furnish incentives to the making of plans. Hence in the other districts development started on the Forests. The most notable case of such development is that on the Snoqualmie.

The supervisor of the Snoqualmie strove to establish sustained yield on each of the four working circles, each representing a watershed or group of watersheds, into which he divided his Forest. He believed that the demand for timber would soon reach the capacity of the Forest, and that it was advisable to direct this demand in such a way that permanent sustained yield, bringing the advantages of permanent transportation and permanent communities, should be established in each working circle. Furthermore, he believed that only by the collection of detailed data beforehand would it be possible to make sure that the cutting would be concentrated on overmature and deteriorating stands; otherwise such stands would be missed, with consequent waste through the decay of the stands themselves and loss in production from the land on which the stands stood. His working plan, together with strong arguments for working plans on the National Forests and a number of sound principles for the guidance of such work, may be found in the Proceedings of the Society of American Foresters, Vol. VI, No. 1, pp. 16-37, 1911. It must be remembered that the need for control in the location of the cut in order to utilize the overmature timber is greater in even-aged stands, such as Kirkland is dealing with, than in uneven-aged or group stands, such as are found on many other National Forests.

Although Kirkland's ideas and plan were excellent, and such as every forester would desire to push through, they encountered obstacles in the form of lack of funds, the money being needed for more immediate purposes, and in the pressure for increased timber sales. Furthermore, control of the location of the cut would have involved sacrifices of stumpage

values which were considered inadvisable. Therefore the detailed provisions of the plan are not being carried out for the present; but the inspiration of the work remains and will be of great value later on when conditions favor more intensive forestry.

Another noteworthy case of a Forest which began to develop a working plan without a general district activity is that of the Deerlodge. Here the demand for mine timbers served as the stimulus. Attention was concentrated on the collection of data, and the plan itself was not started during the period with which we are now dealing.

This period saw, in addition to the above-described experimentation in the actual making of plans, a steady accumulation of general data on timber and other resources. The demand in timber management was for three kinds of information.

First, a general knowledge of the quantity of timber and its location; enough to enable the Service to tell an applicant where the desirable logging chances are and, roughly, how much they contain; then if the applicant is sufficiently interested a detailed map and estimate can be made to use as a basis for the sale. This general knowledge of the timber was secured by rough estimates and guesses. Sometimes "extensive reconnaissance," estimating by the crudest methods, was employed and sometimes the estimates and guesses of the local force were taken. All this information is, of course, constantly being improved through additions and corrections.

The second kind of information in demand was that which would enable proper marking to be done on sales. This involved a certain knowledge of silvics and the use of this knowledge in devising methods of silviculture which should insure natural reproduction. Silvical data were accumulated, before the establishment of the experiment stations, by the silvical reports and by the observations of almost every man who went into the woods. The silvicultural practice was built up by the actual marking of timber in accordance with the existing knowledge of silvics.

The third kind of information required was that on utilization, including methods and costs of logging and manufacture, markets, and selling prices. The collection of this information in every possible way has proceeded actively ever since timber was sold from the Forests, until now a reasonably full and constantly increasing fund of utilization data is available. Therefore during this period, even where plans were not considered, the data on which efficient forest management depends was being steadily accumulated.

PRESENT SITUATION

The present is taken as comprising not only the present moment, but the present period, beginning with the spring of 1912, when the "Standard Outline for Forestry Working Plans" was issued. Strictly speaking, this is not correct because ideas are not the same now as they were in 1912; but the situation will be understood more readily if the entire period is treated together.

Control of Plans

The question which comes up in the management of forests, as in every large enterprise, is how far shall control be centralized. With regard to working plans, the practice abroad has generally favored centralization, the purpose being to have a central control over the provisions which are included in working plans. Since the provisions are always carefully followed out, this furnishes an effective control over the management. Somewhat this idea appears to have been applied in the Forest Plans part of the Forest Service Manual issued in 1911, which provided for the approval of all final working plans by the Washington office. Preliminary plans were, however, not required to be sent in. It must be remembered that at that time a number of plans which would now be considered only preliminary were sent in for approval as final plans. Now that the standard of what constitutes a final plan has risen, timber plans have ceased to come in; and since it will be a considerable while before final timber plans are written, it will be an equally long while, under the present scheme, before such plans come under a central control.

Central control of working plans has another purpose in addition to control of the management through control of the provision of the plan. This other purpose, which applies particularly to a country just introducing forestry, is the guidance of working-plan development in such a way as to insure reasonably rapid progress along sound lines. To attain this end, the centralization must be applied in the first stages of development.

At present the plans for the various lines of activity show various degrees of centralization. Grazing is probably the most highly centralized line, all plans in whatever stage of development coming to Jardine. Unquestionably to this system and to Jardine's ability in handling it is due the remarkable progress in grazing plans. In grazing it has been a question of skilled guidance, not forcing, since the demand already existed. Silviculture, or timber, is centralized as far as control of final plans is concerned, but decentralized in all the earlier stages of develop-

ment, thus losing whatever advantages there may be in a central control of development. Plans for fire protection were decentralized until last winter, when a general call was sent out for all fire plans to be turned in to Washington. This may or may not have been intended as the beginning of a policy of centralization in this work. In the remaining lines of activity—lands, permanent improvements, and general administration—the work itself, except for certain details, is centralized, whereas the plans covering the work are decentralized. This is probably due to the fact that the plans for these remaining activities are, except in one or two districts, in a very early stage of development.

The Standard Outline

One of the features of the present situation is the "Standard Outline for Forest Working Plans," issued by the Forester in May, 1912. This outline is still in force. It need not be reproduced here, since it has been distributed throughout the Forest Service and among most of the forest schools, and is to be found in the "Theory and Practice of Working Plans," by A. B. Recknagel, on pages 192-198.

The fact that this outline has remained unrevised through three field seasons, while most other instructions are revised or at least supplemented yearly, is attributable to the varied degree of centralization and decentralization existing in the different lines of work rather than to the excellence of the outline itself. The part of the outline covering grazing, the only fully centralized activity, was drawn up by Jardine, and is so complete that revision has not been necessary. In the other sections, particularly in silviculture, the modifications thought necessary are made in each district, since the districts virtually control the development in these sections. Although the lack of revision is not due to excellence on the part of the outline, it would be a mistake to infer from this that the outline is poor. Quite the contrary is the case; the outline serves as the basis for the plans development of the districts, and the only modifications now necessary are in details. If, however, Mason's scheme of regional silvicultural plans, as described below, is put into effect, the section on silviculture will require radical changes.

When the outline was first issued the policy was to push working plans vigorously. It was not intended that expense should be incurred in the collection of new data, but that data already available should be assembled as called for in the outline. Wherever the data for any heading given in the outline were lacking, that heading was to be omitted; thus the outline would serve for preliminary as well as for final working plans, the distinction depending merely upon completeness in the treatment of

the headings. If the plan was only preliminary, as it was expected most would be, the data would be constantly added to and the plan revised accordingly, until, when the data were complete, the plan would be final.

Another important feature of the outline was that some sections could be in final form, while others were preliminary, the completeness of each depending only on the information available. At the same time the interrelation of the sections was not lost sight of and each was to be fully coördinated with every other. For example, the improvements called for in the improvement section must depend on the requirements of handling the timber, the grazing, and the fire protection; likewise the degree of protection aimed at in each locality, unless complete protection is possible, will depend upon the value of the timber, as shown in the silviculture section.

It was recognized that great variation in completeness of data existed between Forests; some might be ready for final grazing plans, but have little information on timber; others might be ready for a final fire plan, but have no grazing business, etc. Therefore, in order to make the outline universally applicable, it was necessary to make it complete enough to meet the most advanced requirements along each line. Where any line was in a less advanced stage it would be easy enough, so it was thought, to omit those parts of the outline on which no data were available.

Accordingly, the outline was sent to all supervisors in the hope that, during the winter months, they would assemble all their available information and arrange it, together with a clear-cut policy, in the manner indicated; through this work and the resultant plan administrative efficiency would be increased, and lost motion due to changes of personnel would be saved. Unfortunately the scheme encountered an unexpected obstacle at the start. The very completeness of the outline, which was essential to make it applicable to every stage of plan development, made it extremely confusing to the average supervisor, who was just the man it was intended to reach. Only those who had already thought more or less about plans and those who had a strong enough incentive to devote the necessary energy to studying the outline were benefited. To the majority of supervisors the outline and its purpose appear to have remained a closed book.

From this it must not be inferred that the complexity of the outline is the chief reason why plans do not now exist on every Forest. In spite of the high hopes entertained when the outline was first issued, it is now evident that no outline, however good, will serve to bring forth plans. There must first be a demand for the resource or line of work in question.

Then the normal development of plans requires time; effective plans cannot be made in a few years. The standard outline is merely a step in the normal growth of forest plans and should be regarded as such, not as an instrument for the immediate production of effective plans. Considered from this point of view, the *Standard Outline* has served and still is serving a useful purpose in stimulating and guiding the development of forest plans.

Since each line of forest activity requires distinct treatment, amounting practically to a separate plan, it will be best to take up each line separately.

Silviculture or Timber

General.—When the interest in working plans was at its height in the Washington office and the standard outline was drawn up, it was decided to have two sample plans prepared by members of the Washington office in the two districts in which timber sales were most active. The plans were to cover all lines of forest activity, but since silviculture was the chief incentive to the work, the consideration of these plans properly belongs under silviculture. These plans would, it was supposed, show how the outline was to be used and would serve as models to help all the other Forests in each of these districts. The scheme appeared to be an excellent one, but on at least one of the Forests the plan was far from being the result of normal development. The need of a working plan, except for fire protection, had never been felt, and the demand for timber was far too small to justify a plan. All that was required was more silvical information, definite systems of silviculture, rough estimates of the timber, and utilization data. Since the estimates and some utilization data were already available, the only contribution which the plan was able to make, aside from furthering the working-plan idea, was in silvics, silviculture, and a little utilization data. Fortunately the Forest contained nearly all the important timber types in the district, so that the silvics and silviculture applied not only to the single Forest, but to practically the whole district. Such information would be more effective if collected for the entire region and placed in a single regional silvicultural plan, as in Mason's proposed scheme, which is described below.

On the other Forest, in another district, the development toward working plans had progressed further, and the demand for the timber had reached a point which justified, if it did not absolutely require, a timber plan. Hence in this case, although the data were scanty, the plan was measurably successful.

Since the making of these two plans the interest in timber plans appears, with a few exceptions, to have fallen off rather than to have increased. It is but natural that attention should be concentrated on those activities most in demand, as, for example, fire protection. But why, with increasing sales, should interest in timber plans diminish? There are two reasons: First, timber plans were overdone at the start, owing to the persistence of the idea that a working plan is essential to forestry, and that a working plan is a plan for timber management. The second reason is to be found in the influence of the present method of selling timber upon the demand for regulation of the cut. It must be remembered that foresters have been brought up on the idea that regulation of the cut is the main function of a working plan for timber, and that this idea still persists. Furthermore, if the scheme for regional silvicultural plans is put into effect, it will be true that timber plans will be required chiefly or even only on Forests requiring sustained yield. The first reason has already been sufficiently explained; it is worth while looking a little more closely into the second.

The pressure which has been exerted upon the Forest Service to become self-supporting has stimulated efforts to increase receipts. Since grazing is already producing nearly all it can with the present fees, the only way in which receipts can be increased without increasing grazing fees is by selling more timber. This is being done as rapidly as is consistent with sound business principles and without injuring the sources of supply needed locally. Therefore the timber is sold wherever it is possible to do so without undue sacrifices in stumpage values and without exhausting too rapidly the forests upon which local communities are dependent for perpetual supplies. This means that bodies of difficult accessibility are sold in amounts sufficient to justify the construction of whatever transportation facilities may be necessary to exploit them, provided the cost of construction is not so great as to make the stumpage value of the timber unreasonably low. In these large sales sustained yield is ignored on the ground that such sales, by encouraging the building of transportation facilities, open up the country to settlement. Other industries, such as farming, mining, cattle raising, etc., none of which alone would justify the building of a railroad, are encouraged. There can be no doubt that the opening of the country in this way is beneficial, and is far more important just now than sustained yield, for it is by just such large operations that private timber holdings have been developed in the past and large areas settled up. Furthermore, good silviculture is practiced on these areas, so that the forest-producing capacity of the land is in no way impaired.

Although the stimulus to regional development which comes from large sales of inaccessible timber appears to be ample justification for making these sales in spite of their effect upon sustained yield, yet an additional argument involving dangerous fallacies has been advanced and widely accepted. Many consider this argument as being sufficient in itself to justify large sales.[5]

The argument is that virgin stands contain enormous quantities of overmature and rapidly deteriorating timber, which should be cut as rapidly as possible, in order to save the waste due to decay and to increase the productivity of the land by replacing these decadent trees with thriftily growing ones. The argument is based on unquestioned facts, but facts insufficient to justify it, and ignores economic conditions.

In the first place, the decay, while undoubtedly going on, is slow, much slower than commonly supposed, and will not constitute a heavy loss in 20 or even 50 years. Secondly, the gain in productivity of the soil, while real, has been much exaggerated. The idea that virgin stands contain large amounts of mature and overmature timber is based on *volume, not on area*. That the *area* occupied by overmature timber forms but a small percentage of the total, even where the volume of such timber is large, will be strikingly impressed upon any one who actually maps out this age class on any representative 40-acre plot in a virgin group-selection stand, as, for example, in the sugar pine-yellow pine type of the Sierras. In even-aged stands an accurate age class map covering any considerable area will generally show the same thing. Both the saving of waste through decay and the gain in productivity of the soil will be far more than offset by the economic advantage of having a reserve of large trees containing high-grade lumber. Some men ignore this advantage so far as to advocate rapid cutting to convert the National Forests into good producers, so as to help tide over the coming scarcity of timber. They fail to see that the long-heralded scarcity of timber will be a *scarcity of upper grades*. There will probably always be enough low grades. This is evident in the East, where the upper grades have to be brought in from the outside, while there is plenty of low-grade material from second-growth stands. Therefore the function of the National Forests is to act as a reserve of high-grade material; in fact, it is not difficult to foresee the day when the National Forests will be the sole source of high-grade timber and when "National Forest lumber" will become synonymous in trade with high-grade lumber. To hasten the removal of

[5] See article by J. C. Kircher, "A Proposed Method of Preparing Working Plans for National Forests." Forestry Quarterly, Vol. XII, No. 2, pp. 145-157, esp. p. 150, paragraph 3.

this high-grade timber to save a small percentage of waste through decay or merely to increase the production of low grades would be very unwise.

In addition to large sales to encourage the opening up of inaccessible areas, sales are also encouraged in the more accessible regions, often where private lumbering operations are already under way. In such regions high stumpage prices are received, because the operator can utilize the timber without first building expensive roads or railroads. The concentration of sales in these more accessible regions increases the revenue more than would a policy of deflecting the demand, by slight concessions in stumpage, onto less developed areas to secure a better distribution of the cut. By less developed areas we do not mean the areas so inaccessible as to require large sales to open up, but country where there is already enough transportation to insure sales at reasonable values, though not quite such high values as those secured where the lumber operations happen to be concentrated. The white-pine region of Idaho and western Montana is an exception in that the entire region is so accessible that the sales can be properly distributed among the different Forests without affecting the price received for the stumpage.

This concentration of sales in the more accessible regions has also greatly influenced the demand for regulation of the cut. One example, the Whitman, will serve as an illustration. On this Forest, when the sales were considerably below the annual yield, this yield was fixed as the annual limitation of the cut. Then, as the sales increased and approached this limitation, the allowable cut of a neighboring Forest was combined with that of the Whitman. As the sales on the Whitman increased still more, the cutting budgets of the remaining neighboring Forests continued to be added, until four or five Forests were included in the "working circle," in which practically all the cutting was concentrated on a single Forest. Since all of these Forests did not have a common outlet, as in the ordinary conception of a working circle, but widely separated outlets hundreds of miles apart, a new kind of working circle was devised to cover this and similar cases. This was called the "economic" working circle, which would be a "working circle" including all the Forests in a region tributary to a main railroad system and whose timber went into the general market. The idea was that in such working circles it would be possible for the sales to follow the normal progress of development in transportation, concentrating on each part of the region in turn as it became opened up by the construction of railroads. This, it seems, is merely accommodating the sales to the natural economic development of each region.

The difficulty with such a scheme is that it is so broad as to make it well-nigh impossible to tell where to draw the line. Practically all the timber from the National Forests, except from small sales in isolated localities, goes into the general market, and the main railroad systems over which the timber must go are hundreds of miles in length. For example, all the timber on the Blue Mountain Forests of eastern Oregon, which it was desired to place in one "economic" working circle, is tributary to the Harriman lines and the general market; but so is the timber on the Payette, Boise, and Sawtooth, in Idaho, which is in a different district and which cannot be included in the same working circle. Another less obvious but more serious difficulty is that back of the scheme there is no genuine desire to secure regulation of the cut. Suppose such large and unwieldy working circles were established, and that on one of them the sales reached the prescribed limitation. Does any one imagine that no more sales would be made in that circle?

Since the lumber all goes into the general market and is not needed locally, what is the use of all this juggling? Is it not far better to adhere to recognized basic principles in the making of working circles, and then to acknowledge frankly that circumstances preclude for the present a management on a sustained yield basis? Cutting is being done under safe silvicultural methods, so that the productivity of the forest land itself is in no way lessened. What does it matter, then, if the policy of sustained yield be abandoned for a cutting cycle, or even for a whole rotation, provided the timber is not needed locally? The Service can point to the pressure for increased revenue and to the desirability of selling where the best prices are received as justification.

Large working circles composed of groups of Forests are sometimes due to entirely different causes from those mentioned above and have a correspondingly different influence on the demand for regulation of the cut. In sparsely timbered regions, as, for example, in southern Idaho and in Utah, the annual limitation of the cut by Forests allows such amounts on each Forest as to interfere with even moderately small sales. In such cases it seems desirable to group some of these smaller Forests together, so that reasonable sales can be made on each one in turn, always adhering to sustained yield for the group. This case of large working circles differs from the "economic working circle," in that it is caused primarily by the difficulties which the annual limitations introduce into the handling of sales, rather than to the need for increasing sales and lack of necessity for regulation of the cut. In this case the desired results could be attained by a periodic limitation, allowing heavier cutting some years than others, provided the total for the period is not exceeded.

Under the present timber-sale policy regulation of the cut is attempted only in the more accessible forests of western white pine in Idaho and Montana and in certain localities where the timber is needed for local consumption. The area included in these two cases forms but a small percentage of the total within the National Forests.

Regional Silvicultural Plans.—The smallness of the demand for regulation of the cut, and the growing appreciation of the importance of good silviculture, have given rise to a scheme which will probably have a far-reaching influence on all future working plans for timber.

There has always been a strong feeling that methods of silviculture formed the most important part of a timber plan, for, even though regulation of the cut might be unnecessary or impracticable, good silviculture could not be dispensed with. Therefore many plans treated this subject in great detail, with the idea of contributing something to the silvics and silviculture not only of the Forest in question, but of the entire region. This practice was followed to its logical conclusion by D. T. Mason, while making a working plan for the Deerlodge National Forest. In the course of collecting the data for this plan he secured an enormous amount of original silvical material on lodgepole pine applicable over a far wider area than that covered by the proposed plan. In fact the material collected was so full and so conclusive that it has served, together with material on the same type in other parts of the range, for drawing up a very valuable monograph on lodgepole pine. Since writing this monograph on lodgepole pine, and possibly as a direct result of it, Mason has put forward the scheme of regional silvicultural plans. The scheme is still in the trial stage, but shows great promise. The idea is to include in one full report for each silvicultural region all the material dealing with silvics, silviculture, and utilization, which, under the Standard Outline for Forest Working Plans of 1912, was to have been included in the plan for each Forest.

Possibly the scheme is the natural outgrowth of the present method of collecting silvicultural and market data, as well as an idea suggested by the collection of these data for a single plan. These data have so far, aside from working plans, been collected by each district office for the district as a whole, or for each silvicultural region within the district. It has been sent out to all supervisors from time to time in circular letters as instructions or information. In this way, although it is supposed to accumulate in the supervisor's office, much of it is scattered through the files and forgotten. Therefore the logical and advantageous way of handling this material would be to include it, as Mason suggests, in regional plans covering silviculture and markets. This would merely mean the

assembling and coördinating under one cover of much valuable material that now loses much of its effect by being scattered and unrelated.

The importance of Mason's idea is such that it is worth while giving here the headings which he intended to cover in each regional plan. These headings are, it must be remembered, tentative and may be added to or otherwise modified when the scheme is actually worked out. They are as follows:

Headings for regional silvicultural plan:

Silvical data (types, etc.)
Volume tables.
Market prices.
Standard sale clauses.
General objects of management.
Silvicultural systems.
Rotation.
General sales policy requirements.
Planting policy.
Investigations.
List of trees and shrubs.

Growth data, including yield tables where these can be secured, were probably to be included under silvical data or made a special heading. Market prices would probably include such other information on utilization as would be useful in making timber sales.

Copies of the regional plan are to be given to each Forest supervisor in the region to serve as a basis for handling the timber on his Forest. As he finds differences between his types or local conditions and those described in the plan he can modify the plan to suit these differences. In such cases it will probably be necessary to see that the actual differences do exist and not simply differences due to ignorance or hasty judgment. This point has not yet, as far as we know, been considered, but will doubtless be taken up when the first regional plan is put in force. As more data are accumulated the regional plan can be revised from time to time.

On Forests where the demand for timber is considerably below the possible cut, the regional plan, supplemented with rough estimates of the timber and a rough calculation of the cut, will serve every purpose until the demand increases. Where the demand approaches the possible cut a timber plan will be necessary, but one very much simplified on account of the regional plan. All that the timber plan will then need to cover will be: variations between conditions on the Forest and those given in the regional plan; estimates of timber, with necessary descriptions; regulation of the cut, and policy.

The general idea of a regional plan is to a certain extent applicable to the data required for grazing management as well as to that for timber. The investigative bulletins of the grazing specialists, such as the "Reseeding of Depleted Grazing Lands to Cultivated Forage Plants" and "Range Improvement by Rotation and Deferred Grazing,"[6] are along this line, but the scheme itself has not yet been considered for grazing.

The advantages of regional silvicultural plans are numerous: First, such plans are the logical outcome of certain well-marked tendencies in making working plans and of the present method of collecting silvicultural and market data; second, they will save repetition by placing in one regional plan all the material which would otherwise have to be repeated in the plan for each Forest; third, the work will be better done in the single regional plan than it could be in any one of the individual Forest plans. The third and perhaps the greatest advantage of the regional plan is that it will insure good silviculture on all Forests, even on those where, although a certain amount of cutting is going on, a working plan is as yet unnecessary.

The chief disadvantage, it appears now, is that the regional plans may tend to discourage the collection of original silvical data later on in the making of the timber plans for individual Forests. Although silvical work is being concentrated in the hands of specialists and at the Experiment Stations, yet the man who makes a timber plan is in a particularly good position to secure observations which are of great value in themselves or in suggesting necessary lines of investigation. However, it is by no means certain that the regional plans will have this effect.

Secretary's Limitation of Cut.—Any statement of the present situation of timber plans would be incomplete without at least a brief mention of the Secretary's limitations of cut for the National Forests. To an outsider the fact that a certain fixed limitation exists for every National Forest, sometimes for a group of Forests together, might convey the impression that the government is regulating the cut on all its holdings. A little further insight into the situation would show him that most of these limitations, except in the western white-pine region, are more or less perfunctory and have no great meaning.

In the first place heavy sales are being made in only a comparatively few localities, while everywhere else the demand for timber is far below the producing power of the Forest. Secondly, under the present undeveloped conditions prevailing on most National Forests, it is extremely difficult to decide upon the boundaries of working circles, because it is

[6] Bulletins 4 and 34, respectively, of the U. S. Dept. of Agriculture, by Arthur W. Sampson.

impossible to tell what will be the future lines of transportation and the future outlets and markets. Under these circumstances it has been customary to use the Forest as the unit of regulation, although it is a purely administrative division and bears no relation whatever to working circles. One attempt to have the districts lay out working circles, on the basis of which the recommendations for limitations of cut were sent in, did not prove successful, and it has been decided to go back to the Forest as the unit except where logical working circles can be made. The limitations are calculated by the Von Mantel or, where there are more data, by the Austrian formula, always being conservative.

Although it is generally admitted that these limitations are of no great importance, yet it would be unfair to say that they served no useful purpose. They act as valuable guides to show about how much can safely be cut, and are danger signals at the approach of which it becomes necessary to begin preparations for a working plan to regulate the cut, provided regulation is considered necessary.

The chief improvement which could be made in these limitations at the present time would be to make them periodic, covering 5 or 10 years, instead of annual, wherever an annual limitation interferes with the making of reasonable-sized sales. This would be of value on sparsely timbered Forests, where the annual limitations are so small as to hinder operations of even the smallest size compatible with economical logging. As a matter of fact, it would be more consistent with the present stage of management if all the limitations were periodic. Annual limitations are adapted to intensive management, not to that at present possible on the National Forests.

Kircher's Article.[1]—Kircher's article is of unusual interest in that it comes from the man most intimately connected with timber plans in the district (3) which has been, and perhaps still is, most active in making such plans. His analysis of past failures and suggestions for the future deserve careful consideration.

In the first part of his article Kircher lays great stress upon the length and silvical nature of the plans made heretofore and attributes their failure largely to this fact. That these plans did go in strongly for silvics has been noticed above in this paper under the discussion of Mason's scheme for regional plans. This in itself, however, does not constitute a fault, as Kircher implies. His statement that "important facts and deductions may be hidden somewhere among unimportant details," thus preventing the plan from being referred to when it should

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[7] Kircher, Joseph C. "A Proposed Method for Preparing Working Plans for National Forests." Forestry Quarterly, Vol. XII, No. 2, pp. 145-157, 1914.

be, is a criticism of arrangement of the plans, not of the material which they include. This trouble can be overcome without losing the material. In the first place, the points needed for reference can be sorted out and kept separate; secondly, every plan can and should be thoroughly indexed; and, thirdly, many details which are of value as adding to the sum of silvical knowledge, but which are in danger of being discarded as "useless data," should be placed in the appendix. Kircher suggests placing silvical data in the appendix, but gives the impression that some of the silvical material besides that which belongs in the appendix should be discarded; in short, the danger of Kircher's position is that he tries to attain ease of reference by omission rather than by arrangement.

There is still another solution to Kircher's difficulty, namely, a regional silvicultural plan along the lines indicated by Mason. The first few pages of Kircher's article comprise an argument, all the stronger for being an unconscious one, in favor of such regional plans. All of District 3 lies in a single silvicultural region, the western yellow-pine region of the Southwest. Hence a regional plan would not be very difficult to draw up, particularly since so much silvical material has already been collected, and would solve all the difficulties arising from too great length and detail in the plans for individual Forests.

His third point, about the present plans failing to take into consideration the inaccessibility of the timber, is just. This is due largely to the over-optimistic point of view which the maker of almost every plan unconsciously acquires toward the development of the region with which he is dealing. Furthermore, it is always more conservative to plan for the more intensive operations, because if such operations prove impossible, the intensive provisions can easily be passed over, whereas if less intensive operations than circumstances eventually permit have been provided for, it is a difficult matter to reconstruct the whole scheme on a more intensive basis. Of course, there is a happy medium which good judgment and foresight will indicate.

Kircher's ideas on regulation of the yield (page 148) afford an excellent illustration of the influence of the forces which we have just described in the preceding pages upon men's ideas of regulation of the cut. His almost complete abandonment of all regulation is by no means an unusual point of view. Present conditions are making this the common doctrine, except in the western white-pine region and in a few areas supplying local communities.

His conclusion that the annual cut should be based upon "what can and must be done" (page 148, italics, and page 149, last paragraph), and not upon sustained yield, is worthy of attention. The idea seems to be

simply for the plan to lay down a cutting policy in accordance with the accessibility of the timber, providing for large sales where the inaccessibility of the timber renders such sales the only feasible method of exploitation. So far, so good; this is merely common sense. But Kircher does not appear to have given full consideration to a universal application of his principle. Where most of the timber is of difficult accessibility, his principle will probably work out all right; it merely proposes to put into the form of a plan that which is already being done without a plan. In this respect it is a step in advance. But what about those Forests which are not so inaccessible as to require large sales? His principle would abandon regulation on all these, even in the western white-pine region.

The argument for extensive cutting in order to remove the overmature timber and convert the National Forests into "good producers," so as to help tide over the coming scarcity of timber (page 150, paragraph 3), is based on errors, which have been discussed above on pages 32-34.

Under the proposed plan drawn up by Kircher and Woolsey, the first point, card records, is not clear. It is uncertain whether the tabulations themselves are to be placed on the cards or whether the tabulations are to be kept on separate sheets, each sheet with a corresponding card reference. The former seems to be the meaning of paragraph 1 on page 153, but does not look reasonable, owing to the difficulty of squeezing long tabulations, as, for example of estimates, in the small space permitted by cards, while if the tabulations are split up to go on cards, the confusion will be endless. The scheme of having card references to tabulations well arranged in a separate place seems, if that is meant, to be a good one.

The second point, the annual plan, is an unconscious indication of the tendency to build up plans by a gradual process of development from the annual stage to the preliminary and then the final stage, as described below under "Future Development, Development and Kinds of Plans." Though this conception of the evolution of plans may not have been thought of directly in connection with Kircher and Woolsey's scheme, yet the working out of their scheme will eventually be along such lines. If the annual plans and data are good, they will suffice, and the preliminary plan can wait a few years. Therefore these men have started, probably all unconsciously, a direct practical application of one of the fundamental principles in working plans—the principle of normal growth.

Their conception of a preliminary plan will serve as a wholesome check on the present drift toward lifeless inventory plans. Particularly re-

freshing is this statement: "In the past preliminary plans have been considered by some as mere inventories of resources. They should be more than this. . . ." The inventory will come under the card record, and the "preliminary plan . . . will be a true plan of management for the Forest." The idea of limiting the area covered by the plan to the Forest, allowing smaller units if necessary, is another good one.

The making of plans by specialists rather than by the supervisor has always been one of the tenets of District 3 and is ably defended by Kircher. He might have added that the chief argument in favor of having the supervisor make the plan, namely, that otherwise the supervisor fails to take interest in the plan and consequently does not follow it, is answered sufficiently by having the supervisor make the annual plan. Under the working out of Kircher and Woolsey's scheme the plan will be developed by the supervisor through its simplest stages, the annual plan, until it reaches a higher stage, the preliminary plan, when it will unquestionably be advisable to call in the assistance of a specialist. The suggestions as to subjects which should be included in preliminary plans are good except for the danger involved in the rather too hostile attitude toward regulation of the cut—an attitude which comes from the point of view expressed in the first part of the article.

On the whole, Kircher's article is a most timely and valuable contribution to the subject of timber plans, containing many helpful suggestions, and will, it is hoped, provoke the discussion which the author solicits.

Grazing

Grazing plans were undertaken long after timber plans, but have progressed far more rapidly, more uniformly, and with less complications. The reason, aside from the skill with which the work has been handled, is that grazing plans have been more needed than timber plans and easier to follow after once being drawn up. In the first place, the demand for forage is far greater in proportion to the supply than the demand for timber, and on most Forests is strong enough to justify the making of plans. Secondly, a far greater degree of control can be exerted over grazing than over timber sales. The number of stock allowed on the Forest and the areas to be used can be controlled almost absolutely, whereas the amount of timber sold and the location of sale areas depends almost entirely upon the wishes of the purchasers. This is, of course, a temporary condition in timber, due to the smallness of the demand. Therefore grazing plans are on a firm basis, because they have been made in response to the demand and because their provisions can be carried out.

The development of grazing plans has been further hastened and guided along sound lines by the concentration of control under J. T. Jardine, in the Washington office. Jardine, with the assistance of a small force, among whom is A. W. Sampson, whose studies in forage plants have revolutionized methods of grazing, has accomplished wonders. The grazing plan for every Forest, after passing through the district office, comes to him each year. In this way he is enabled to keep his hand on the grazing business of the entire Forest Service and to put into effect improved methods as soon as they are discovered. He has not only opened up much hitherto unused range through the construction of watering places, drift fences, etc., but has, through rotation grazing and improved methods of handling stock, restored enormous areas of overgrazed range to their full carrying capacity without even temporarily reducing the number of stock.

Fire Protection

The present situation of plans for fire protection presents the best example of the principle that a demand for the resource or line of work is the first requisite of a plan. The strong demand for fire protection has made the development in fire plans more rapid than that in any other line of work.

The activity in fire plans may be said to have begun on the Forests themselves. It is true that the district offices sent out instructions to all supervisors to prepare plans, but the fact remains that the Forests, taken as a whole, were ready for this work and needed very little urging. These plans were made by the supervisors and handled entirely by the districts. Whether some of them should have been sent into Washington as final plans is difficult to decide, because it was next to impossible in this case to draw the line between the preliminary and the final plans. In any case, the fact that all fire plans were called for by the Washington office shows that, even though there may have been no idea of centralizing this work, yet it was considered advisable for a central office to keep in touch with developments over the entire field.

It is unnecessary to go into details with regard to the contents of fire plans. The bulk of a fire plan is placed on a map showing topography, roads, trails, telephones, lookout points, patrol routes, location of tools and supplies, ranches or villages, with number of fire-fighters available in each, and any other similar information which can be represented graphically. The headings to be covered by the written matter are fully given under Section V, Protection, of the "Outline for Forest Working Plans" of May, 1912, reproduced on pages 196-197 of Recknagel's

"Theory and Practice of Working Plans." There are differences between fire plans, due to varying local exigencies and to the individuality of different supervisors, and some plans are better drawn up than others; but all plans are serving the purpose of increasing efficiency in protection against fire.

Just how much these plans had to do with the remarkable effectiveness of the protective system in the past fire season (1914), in spite of the fact that the unprecedented drought made conditions even more dangerous than in the disastrous season of 1910, cannot at present be told for certain; but it is likely that a large portion of this remarkable fire record was due to the carefully drawn plans of the few preceding years.

Lands, Improvements, and Administration

Lands, Improvements, and Administration each require a separate plan, or to be more exact a separate section of the Forest plan, but for convenience the present situation of all three will be considered together. Since these subjects are the ones least known outside of the Forest Service, it may be well to give the main idea of each in a nutshell—the details can be found under sections IV, VI, and VII of the 1912 outline for Forest plans, reproduced on pages 196, 197, and 198 of Recknagel's "Theory and Practice of Working Plans."

The Lands section covers settlements, administrative sites, and resources other than timber and grazing, such, for example, as water power, camp sites, etc.; in a word, Lands covers the use of land and all resources except wood and forage, both by the government and by others. The Improvement section covers the construction and maintenance of all permanent improvements, such as ranger cabins, fences, trails, telephone lines, lookout towers, etc., for whatever purpose required. The Administrative section is the plan of administering the Forest, and gives the division of the Forest into ranger districts, with the area and forest business on each, together with the force required to handle this business. It therefore amounts to a summary of the work covered in all the other sections of the plan and the force required to perform this work.

There is a heavy and pretty uniformly distributed demand for the work called for by each of those three lines of activity.

Under Lands the settlement policy requires the listing of all potentially agricultural land not required for administrative purposes as rapidly as possible. This requires the services of special land examiners and, where there are large bodies of agricultural land, of special land classification parties. At the same time it is necessary to reserve administrative sites at strategic points for stationing the rangers, who must

handle the timber, grazing, and other business. When a resource is as yet undeveloped, as in the case of timber, it is difficult to select the most advantageous locations, for it is difficult to tell where the activity will center. In addition to administrative sites it is necessary to reserve locations which must be used in connection with developing the timber, such as mill sites, decking grounds for logs, rights of way for roads and railroads, etc.; for if a piece of land, over which it will some day be necessary for a purchaser of National Forest timber to build a railroad, is listed and passes into private ownership the timber-sale business of the Forest Service may be seriously handicapped. The owner, if so inclined, could cause much trouble by refusing to sell a right of way, and might even prevent a sale. The difficulty in dealing with this situation at present is that it is almost impossible to tell so long beforehand just where the mills, lines of transportation, etc., will be located. To determine this would require detailed logging plans of every National Forest, an obviously impossible task. Under these circumstances it is necessary to judge as nearly as possible where the mill sites, rights of way, etc., will be located and, when they fall on potentially agricultural land, to provide for reserving the necessary space. Whether such reservations are placed in the Lands section, where they logically belong, or under Silviculture, to remove the onus from the men doing the Lands work, makes little difference. The essential point is that the work of selection be done, and done quickly, because the agricultural land is being rapidly listed.

Under Improvements the demand is for a far-sighted and consistent policy, in order that not only the most needed improvements be constructed first, but that all the improvements shall be definitely related to each other and form parts of a well-arranged system. Otherwise improvements constructed from year to year may be so unrelated as to eventually require alterations, replacements, or additions, involving heavy expenditures, which would have been saved had the improvements been carefully planned in the beginning.

The demand for plans of administration is obvious. Efficient administration is impossible without some sort of a plan based on a thorough knowledge of Forest business and specifying how this business is to be handled.

The demand for plans in each of these three lines of activity has been filled in the past almost entirely by the supervisors' regular annual reports and annual plans on these subjects, supplemented, particularly under Lands, by reports on special cases. Under improvements there has been a tendency to include in the annual plan a statement covering all projects required for five years, from which projects those for the ensuing

years are selected. In some districts, notably in 3, working plans, as distinguished from annual plans, have been required for each of these lines of activity. In District 3 these plans have already, it is stated by one familiar with conditions in that district, been of great benefit both to the supervisors and to the district office.

Private Working Plans

Although the government has, as is to be expected, been the most active of all forest owners in making working plans, yet it would be a great mistake to imagine that no other timberland owners had been engaged in this line of work. A good example of what can be done for a corporation which owns woodlands and which has an incentive to keep its lands permanently producing timber is to be seen in the working plan for the woodlands of the New Haven Water Company by R. C. Hawley.[8] Here circumstances are peculiarly favorable, in that the author of the plan is so situated that he can be constantly in touch with the operations and can see that his provisions are carried out and revised when necessary.

A number of the larger paper companies in the Northeast, though they may have no definite working plan on paper, still are operating under pretty definite plans, with the idea of keeping their lands producing timber permanently.

FUTURE DEVELOPMENT

Having now seen something of the past history and present conditions of working plans, we are in a better position to decide upon a sound course to follow in the future. There will probably be as many different ideas for the future as there are interpretations of the past history and present situation. But it is hoped that, although there may be disagreement on details, a full discussion of the subject may bring about a concurrence of opinion and unity of action on the main points.

Objects of Forestry Plans[9]

Forest plans have two objects: First, to aid the supervisor in systematizing and controlling the management of his Forest upon a definite basis, which represents the cumulative experience and information acquired; second, to aid the district office in making allotments, in coördinating the work, and in avoiding inconsistencies between the individual Forests of the district.

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[8] Bulletin 3, Yale Forest School, 1913.

[9] Adapted from material on Policy and Procedure in Forest Plans, worked up tentatively by the author for inclusion in the proposed Forest Service Manual on Forest Plans. The term Forest Plan covers all kinds of working plans, in whatever stage of development.

Both of the foregoing objects could have been intended by the wording of the paragraph on "Object" in that part of the National Forest Manual covering Forest Plans issued November 1, 1911, which runs as follows: "The object of the Forest plan is to systematize and control the management of each Forest upon a definite basis." . . . But the common understanding of that object stated in the Manual was systematization and control on the Forest itself. The value of the plans to the district office is something which has been particularly demonstrated in the development of working plans in District 3 since the Manual was issued.

The advantages of a Forest plan, even though based on rough or insufficient data, and these advantages may also be considered objects of making a plan, are as follows:

First, the mere work of putting on paper one's information and plan of action is a strong stimulus to clear thinking. By requiring more thorough consideration of the questions involved it crystallizes ideas which had hitherto been vague and gives rise to new ideas. Experience has shown this point to be one of the utmost importance, especially in plans made by the supervisors themselves, either with or without outside assistance. It has been generally overlooked because many supervisors feel that when they have the information in their files and have a fairly consistent plan of action in their heads or in their policy folders, the writing up of a plan is just so much "paper work," involving a great expenditure of time and energy for nothing.

Second, any plan which gathers together and systematizes all the available information and lays down a certain line of action cannot fail to reduce the cost and increase the efficiency of handling the work in question. The making of the plan will reveal deficiencies in information and leaks in administration; one part of the Forest may be receiving entirely too large a share of the expenditures and another part too little. Such discrepancies can be checked up only by a careful tabulation and study of the forest business in each part of the Forest, not by a general impression.

Third, the plan reveals to the district office any weaknesses and mistakes which exist in the supervisor's administration of the particular line of work covered by the plan and allows the district office to correct the trouble. The plan will reflect the supervisor's method of handling the work and will show his weak as well as his strong points. Without plans it is necessary to rely entirely upon inspection by district officers to learn these things. Inspection is costly, involving heavy traveling expenses, and is slow and uncertain. Correspondence can never entirely replace personal visits, yet its effectiveness can be greatly increased and the traveling expenses so much reduced as to save an appreciable sum.

Fourth, the plans allow the district office to make the most effective allotment of funds among the different Forests, to coördinate the work on all Forests, and to avoid inconsistencies between different Forests. Without plans the allotment of funds among the different Forests is a difficult matter. It is impossible for any one man in the district office to be equally familiar with all Forests, and a combination of the information of several men with different points of view will not secure a uniformly effective distribution of funds. The supervisors' annual reports do not solve this difficulty, because each supervisor has a different conception of the importance of any given work, and the reports are not sufficiently detailed to show how affairs are being conducted. Without plans there is always the danger that the supervisor who is most insistent will receive the most money.

Development and Kinds of Plans

Sound plans must be the result of normal development. This, it will be remembered, is one of the two principles stated under "Point of View" at the beginning of this paper. The commencement of a realization of this principle is characteristic of the present situation, but a full realization of it has not yet penetrated all quarters.

Normal growth means passing through lower stages. It must not be expected, however, that the various stages will always be sharply definable; they will often merge more or less into one another. The old idea, as it found expression in the Forest Plans Manual of 1911, was that three kinds of plans were necessary—the preliminary plan, the working plan, and the annual plan. The preliminary plan is a forerunner of the working plan; on account of lack of data it must be incomplete, and hence preliminary to the final working plan. As more data are accumulated the preliminary plan will grow more complete until finally it becomes a working plan. The annual plan consists of the annual reports, estimates of expenditures and recommendations, submitted by the supervisors for various lines of Forest work, each line of work requiring a separate plan. The annual plan for silviculture includes the recommendations on maximum and minimum stumpage prices and the yearly limitation of the cut; that for general administration includes the expenditures estimated to be necessary for the ensuing year and their allotment, and so on for each line of Forest work.

From the point of view of the Manual, the annual plan is a definite plan of action for the coming year, sometimes giving, though very briefly, a reason for the action. It was to be based on the preliminary plan or working plan where any such plan existed. The fact which escaped at-

tention is that the annual plan contains the first crude elements of the working plan. It is the forerunner of the working plan rather than merely an instrument for executing the yearly provisions of the plan or yearly ideas where no plan exists—that is, the annual plan is in reality the first stage of the working plan. It is important to fix this point clearly in mind.

The first to realize the relation of annual plans to the broad problem of working plans was J. T. Jardine. With his characteristic grasp of the situation he saw that the annual grazing plans were in reality the first stages of preliminary grazing plans. So he cast these annual plans into such form that they would serve for the gradual accumulation of data until, under the normal process of growth, they would eventually develop into final grazing plans. The example is an important one for all lines of work and will have a very valuable effect if properly understood and acted upon. The annual plan can then without difficulty be cast into such form that it will not only serve administrative needs, but will encourage the accumulation of data and will start the supervisor thinking of Forest plans. In this stage the plan might be considered a temporary plan, though the term is immaterial, only it should not be confused with the annual plans of action which will probably be necessary even after final plans have been constructed. The main idea is that this plan corresponds with the stage in which there is a demand for at least a rough plan, but in which the data are insufficient or too subject to change, or conditions too uncertain to allow the construction of a plan which will hold good for more than a single year.

The second stage of the working plan may be termed the preliminary plan. This corresponds with the stage in which the acquisition of data or the stability of conditions has reached a point which allows the construction of a plan that, although subject to constant revision, will hold in the main for a period of three to five years.

The third stage may be termed the final plan. This will come when the development of the region has reached a point which allows conditions to be foreseen with reasonable certitude for a considerable number of years ahead, and when enough accurate information on the Forest resource or line of work in question has been collected to permit prescribing the details of handling this resource or work for ten years or more to come.

It is immaterial whether or not terms are used to designate the foregoing stages in the development of Forest plans. The first stage might be called "temporary plans" to distinguish it from the annual plans of action, the present "annual plans," which may always be necessary for

administrative reasons. The second stage fits in with the already well understood term preliminary plan. At the district foresters' meeting in the spring of 1914 the consensus of opinion appeared to favor dropping the term preliminary plan and calling everything merely Forest plans for simplicity. Though this action may be justified on the ground that the stages shade into one another, and that more than one stage may be represented in the same plan, yet it seems hardly worth while arbitrarily destroying a landmark which has been pretty generally understood and accepted. Nevertheless the point is not of great importance. Terminology cannot alter the evolution of plans, though a lack of terms may veil this evolution from the eyes of those who have not studied the subject.

Development in Each Line of Forest Work.—Since each line of Forest work requires a separate plan, though all may be correlated, it will be best to consider each separately. The policy for each must depend upon the situation and needs of the work in question; there can be no rigid rule for all alike.

Silviculture or Timber.—The sort of a timber plan required depends entirely upon the demand for the timber and upon the timber sale policy. A plan for regulating the cut is necessary under the present sale policy in only two cases: first, where demand for local use nearly equals the production of the area tributary to the local market; second, on Forests in fairly accessible regions where the demand, although for the general market, can, by restricting the cut on one Forest, be deflected to other Forests without reduction in stumpage prices.

On all other Forests a timber plan, though extremely desirable, is not indispensable, provided the following data are available: First, a rough inventory of the timber sufficient to establish a rough limitation of the cut and to show prospective purchasers where the desirable logging chances are located; second, enough utilization and market data to insure fair stumpage prices on small sales—for a large sale more detailed data, collected by the district office especially for the sale or in connection with other large sales, will be necessary; third, enough silvicultural data to insure marking of the timber for the highest good of the Forest consistent with the requirements of the market and with the necessary methods of utilization. All three of these classes of data are already available for practically all Forests—more complete for some Forests than for others—and are being constantly added to. If Mason's scheme of working up the silvicultural and market data into a plan for each region, as described under "Present Conditions," is adopted, these data will be just that much strengthened, and the need for a timber plan on each Forest will be correspondingly reduced.

Under these conditions it is probable that timber plans, except where regulation by the cut is essential, will be prepared only after other more urgent lines of work have been covered. This is reasonable, much as one may regret the delay in securing timber plans.

The evolution of plans for handling timber must be different from that of plans for other resources or lines of work. In timber the emphasis is on accumulating and systematizing the data rather than upon the plan of action, as is the case with most other activities. The reason is that action, which means selling timber, is, under present conditions, almost entirely dependent upon the wishes of the purchasers, which in turn depend upon the lumber market. Hence control of action, except for the power to restrict sales, rests with the management only in an insignificant degree, and plans of action would therefore be meaningless.

Development through plans rewritten yearly, as with grazing and other activities, is impossible in timber, not only because of lack of control over action, but also because the data in a timber plan are of such nature that, although it can be revised and added to from year to year, it cannot be completely rewritten without enormous expenditures of time. The early stages of timber plans may therefore be considered to be stages of collecting data, and these stages are now being passed through.

Development will be hastened and made more certain if, during the stage of data collection, the data be more systematically arranged. For example, the silvicultural and market data can be arranged in a regional silvicultural report or plan, as proposed by Mason. The data for individual Forests, such as estimates, forest descriptions, silvical observations, differences between the conditions on the Forest and those described in the regional plan, and other necessary material, can be assembled and coördinated by each supervisor; the results of intensive reconnaissance can then be tied in directly with this data instead of being kept as separate and more or less unrelated information as at present. Some arrangement of data, not necessarily as just suggested, is already being made on a number of Forests and will become more wide-spread as soon as there is sufficient incentive in the form of increased timber business and as soon as the details of arrangement have been satisfactorily worked out.

Another point to consider is the relative value of centralization and decentralization of control. It has been shown that in grazing centralization has been effective in both guiding and stimulating development; but in timber the early stages of development consist largely in the accumulation of data instead of in plans of action. Hence centralization in timber plans appears to be less needed and to offer more complexity than in other lines of activity.

Grazing

The evolution of grazing plans is comparatively simple, passing from the annual plan through the preliminary to the final plan. The annual grazing plan is a combined report on conditions and plan of action; thus it is not merely an administrative plan of action as at first intended, but a true working plan in the rough, based on scanty data and covering only the brief period of a year. The idea is to collect more and more data each year under the annual plan until enough has been secured for preliminary and then for final plans. Where the grazing business is especially heavy and important, the period of collecting the data can be shortened by grazing reconnaissance and a more advanced plan prepared without delay.

After final grazing plans have been prepared, it will probably be necessary to retain some sort of an annual grazing plan giving certain details of managing the range and handling stock which would not properly belong in the broader periodic plan. This annual plan will also have to give information on range conditions, because the forage crop, unlike timber, is subject to considerable seasonable variations caused by climatic fluctuations.

Protection

The future development of fire plans will probably continue to be as rapid as it has been in the past few years, until every Forest has a plan which is as good as its facilities permit.

Fire plans are in a totally different position from timber and grazing plans in that their effectiveness depends not so much upon the data on which they are based as upon the facilities available for protection and upon the experience and generalship of the men making and executing the plan.

The two classes of data representing the greatest difficulty are, first, the liability, or value of destructible resources, and, second, the hazard or risk; for it is essential to apportion the protection money not only on each Forest, but throughout the entire Service, in such a way that the areas bearing the most valuable destructible resources and subject to the greatest risk shall receive the highest degree of protection. But in both of these classes of data figures of absolute accuracy are probably not of much greater value than approximate figures which give reliable information on the *relative* liability and risk in different localities. Even with full data available the protective measures must depend upon methods of communication, lines of transportation, lookouts, and other necessary facilities; and the use which is made of these facilities depends in turn upon the experience, judgment, and generalship of the men intrusted with drawing up and executing the plan.

Fire plans will probably have to be entirely redrawn annually for the next few years at least, because of the changes necessitated by the addition of new facilities, and more particularly by the acquisition of experience; for it is unreasonable to suppose that any one, unless possessed of unusual experience and remarkable generalship, could at the first attempt draw up a plan which would hold for more than one season with only the revisions required by added facilities. Eventually, when sufficient experience has been gained and most of the necessary facilities acquired, fire plans can be made in such a way as to hold for a period of years with only minor revisions. Hence, while the development of timber plans and grazing plans follows the collection of data, the development of fire plans follows the construction of facilities and the acquisition of experience.

Protection against other damage, such as insects, fungi, mistletoe, etc., is difficult to handle in plans because of the sporadic occurrence of most of this damage and of the difficulty and expense of control measures, combined at present with lack of definite data on results.

Lands, Improvements, and Administration

The development of Land plans will probably not be rapid, because much of the work must be handled as special reports. This is particularly true of land classification. Administrative sites are also handled largely as special reports, but would gain by being placed in a plan. The other resources which the section covers—water-power, camp sites, etc.—hardly need treatment in a Forest plan at present; water-power is too complex for the individual Forest to handle, and camp sites, hotel sites, etc., merely require a statement of policy.

Improvement plans may pursue the same course of development as plans for other lines of work, but will reach a totally different goal in the end. This is because improvement work, except for maintenance, is temporary. When all or most of the necessary improvements have been constructed the need will be only for maintenance. There will probably always, even after periodic plans have been made, be a demand for annual plans giving the new projects, until all are completed, and maintenance for the ensuing year.

Plans for General Administration will probably develop with reasonable rapidity because they are needed for efficient administration. These plans, like fire plans, are being built up as the result of experience rather than as the result of accumulations of data. They will probably have to be revised yearly as the opening up of the Forest resources progresses and cannot reach final form until every Forest resource is utilized to its fullest extent. Annual plans, covering the budget for the ensuing year, will always be necessary.

DEVELOPMENT OF SILVICULTURAL WORKING PLANS ON NATIONAL FORESTS IN THE SOUTHWEST

BY JOSEPH C. KIRCHER

Contributed

In Volume 12, No. 2, of the Forestry Quarterly, in an article entitled "A Proposed Method of Preparing Working Plans for National Forests," the writer of this paper gave his ideas of the kind of silvicultural working plans which can now be made for National Forests and which are necessary. It was not contended that the plan suggested would be final, but rather that it was a makeshift based on present conditions and the present very limited information concerning the growth and yield of stands. During the past year this idea has been further developed. The fundamental idea expressed at that time has been adhered to, although many of the details have been changed.

After much thought on this subject, the conclusion reached was that the amount and distribution of the cut is not dictated by the silvicultural requirements of the stand nor on the basis of a sustained annual or periodic yield, but rather by markets and accessibility of the timber. At the present time the Forest Service has not the growth and other data, nor has it the accessible stands of timber, both of which are necessary for the construction of plans in accordance with European ideals. It is obviously out of the question, therefore, to apply European methods used on forests which have been under management for many years to the conditions of the inaccessible virgin forests existing on the National Forests. Even though sufficient data were on hand to predict definitely the sustained annual or periodic yield of a forest, it would be impracticable to base the annual cut strictly upon this, since both the amount and distribution of the cut must depend so largely on local conditions and upon markets. If it is granted that it can be told what should be done, there still remains the question of what can be done. For this reason, at the present time the silvicultural ideal must be sacrificed to local business considerations. Before beginning the construction of a silvicultural plan, therefore, an intimate knowledge of local conditions, including the amount of overmature and inaccessible timber, markets, and the amount and location of the timber must be obtained. With these data on hand, a preliminary plan may be attempted. It is the aim of the plan to establish a definite policy for handling and perpetuating the

timber resources of a given forest. This includes the establishment of a timber sale, free use, and forestation policy. All other things in the plan must be subordinated to these.

Based upon the considerations set forth above, the idea of an annual plan by supervisors and a 10-year plan, supplemented by maps, statistics, and appendix of silvical and other data by specialists, has been tentatively adopted in Arizona and New Mexico.

The annual plans have already been put into effect. The first set of these, which were submitted in March, shows them to be entirely practical and that they have found favor with supervisors. Besides saving time in the supervisors' offices by systematizing the work, they bring to the attention of the district office mistakes which have been made in the past, interesting facts concerning the forests, and proposed changes in policy. They give supervisors a place to express their ideas, and obviate a number of reports heretofore required from time to time throughout the year.

Progress with the 10-year plans has been very slow because of the difficulty of the subject and because of the lack of specialists in this line in the district. Broadly speaking, there are two classes of forests, considered from the standpoint of the 10-year plan—the reasonably accessible forest and the remote, inaccessible forest, where very little or no cutting can be done in the near future.

On the inaccessible forests there is little need of a 10-year plan, since on many of them it is doubtful whether cutting will take place within such a period. Here, ordinarily, the subject may be dismissed with a short, concise statement of timber sale and forestation policy, based on rough data collected by the supervisor in the past. This expression of policy should be the joint work of the supervisor and the assistant district forester in charge of silviculture in the district.

On the accessible forests 10-year plans are badly needed. From a timber-sale standpoint, it is important to determine what there is to sell on such forests and how much and where it can be sold. Preliminary to the establishment of such a plan two steps are necessary. In the first place, it is important to find out how much timber there is and how it can be logged. This is done by a complete estimate (by forties and logging units) of all the timber on the forests and by a division of the forest into logging units. At the same time logging data for each unit are collected. When the field work has been completed the data may best be arranged in graphic form, supplemented by descriptions and estimates. In District 3, two topographic maps on the scale of two inches to the mile are made for each logging unit within the forest. One of these is a type

map and the other a logging map. The latter shows proposed mill sites and roads, distances to markets, and areas of accessible timber. For convenience, these maps are mounted on atlas-sized (18″ x 21″) sheets. In addition, a location map showing the position of the unit on the forest, a forest description with special reference to logging data, and estimates by species are mounted on the same sheets. In this way the most detailed data necessary for the unit are filed in one place in the most concise form.

The second step is a complete market study of local and export markets in Arizona and New Mexico. The study will show the amounts, kinds, and sources of material used in the various markets, the reasons why lumber and other forest products from outside come into the two States, freight rates, and all other factors which have a bearing on supplying local markets and the possibility of export markets for local timber. In addition, the amount of lumber from local private timber holdings is determined, since this enters into direct competition with timber from the National Forests. The study shows where new markets for National Forest products can be developed, where the present markets can be increased, which markets are closed to National Forest timber (with reasons), and whether there are prejudices against certain species of timber, and why. The ultimate object of the study is to increase closer utilization and sales of National Forest timber, provided this is desirable, and to find markets for special products.

The estimates of stand, logging data, and market data having been obtained, and the object for which each individual forest is to be managed having been fixed, the timber sale, free use, and forestation policies may next be stated in a 10-year plan. The expressions of policy, then, constitute the true working plan, and all other parts of the plan, such as silvical data, discussion of types, etc., must be subordinated to them.

In the above argument the writer does not intend to convey the idea that a policy to sell all timber possible should in all cases be adopted. The idea which it is intended to convey, however, is that without a minute study of markets and of timber resources a wise policy of utilization cannot be fixed, and conversely a working plan cannot go much further than prescribe such a policy.

The study, as outlined above, will show what can be sold, and it is necessary, therefore, for the policy to express only what should be sold within these limits of possibility. The accessibility of the timber and the market will determine the distribution and the maximum amount of cut which is at the present time possible, while the sale policy will determine within these limits the amount which will actually be placed upon

the market and the distribution of this amount. The amount to be cut under this policy should be checked by some theoretical method for regulation of the yield, not so much with the idea that the policy will be changed to conform to the maximum cut under the theoretical method, but rather as a matter of comparison and as a safeguard in the ultimate establishment of a sale policy. Because of the lack of accurate data, this check must necessarily be very rough. The object of a preliminary 10-year plan is, therefore, to sum up as a timber-sale policy, a free-use policy, and a forestation policy, brief discussions on the subject of management, markets, present logging, and forest types. When this has been done, there remains only for the plan to describe the silvicultural methods under which these policies will be carried out. These, of course, hold an important place in the plan.

As stated at the beginning, the proposed preliminary plans are only a makeshift. In the opinion of the writer, however, they are entirely adequate at the present time to safeguard the interests of the United States in handling the National Forests in a wise and conservative way. Ultimately, elaborate, final working plans, covering long periods, must be made for all National Forests. These, however, need not be considered for many years. In fact, they are not desirable until sufficient data are gathered to plan the wise use of the Forests for many years to come and until much of the overmature and decaying timber has been disposed of. In the meantime the preliminary and annual plans as described above offer, in the opinion of the writer, an immediate solution which is practical and which will conserve the National Forests in a wise and efficient manner.

WINDFALL DAMAGE IN SELECTION CUTTINGS IN OREGON

BY KAN SMITH AND R. H. WEITKNECHT

Contributed

Under the present system of selection cutting in western yellow pine as practiced by the Forest Service, an unexpectedly severe loss from wind storms has occurred on the Whitman National Forest in Oregon. On this Forest several large yellow-pine timber sales are in progress, and have been since 1911, so that there are now in the aggregate some 6,000 acres which have been cut over by the selection system. The marking on these sales has been done by the usual standard method, leaving evenly distributed about 20 per cent of the thriftiest, soundest, and youngest trees of the original stand, except for a small area where the marking was groupwise. The usual precautions against leaving trees liable to windthrow have been taken, and at first no particular apprehension was felt that there would be an undue amount of loss from this source.

Then came a storm on May 26, 1913, which blew down 792 yellow pines on 880 acres of cut-over land on the W. H. Eccles Lumber Company sale. And on September 18, 1914, there occurred another severe storm, in which 808 yellow pines blew down on the 1,624 acres cut over up to that time. This meant that 969,876 feet, or 17.5 per cent by volume of the reserved yellow pines over 12 inches in diameter, had been windthrown on this one sale area—a loss in two years which, if continued, would mean in a few years more the total loss of the reserved trees. Curiously enough, on an older cut-over area of somewhat similar topography and forest conditions lying 2½ miles distant—that of the Baker White Pine Lumber Company—the loss was but a sixth as great. Here only 441 yellow pines were thrown in the two severe storms on about 2,280 acres—a loss which, though heavy, is not alarming.

The above figures, and those used later in this article, do not include the loss by wind of larch, Douglas fir, lodgepole, and white fir; these species are even more subject to windfall than yellow pine.

To find out the principles which control windfall, so that this loss can be guarded against in future cuttings, a study was started immediately after the September blow-down. It was exceedingly detailed in character. A 100-per cent cruise of the 1,624 acres of the Eccles sale was made; each windfall was described specifically as to its size, trunk, roots, crown, relation to neighbors, soil hold, relation to topography,

etc.; a 16-inch-to-the-mile topographic map was made of the whole area, and a 1-inch-to-50-feet map made of a part of it, upon which the position and index number of every windfall are shown graphically. Almost as intensive a study was made of the Baker White Pine Lumber Company area.

This detailed record of 3,621 windfalls, 2,160 of which were yellow pines, on nearly 4,000 acres of cut-over land, resulted in an exhaustive report containing enormous mass of data, which, reduced to simplest terms, is about as follows:

1. No diameter class over 12 inches is immune from windthrow, although the trees under 18 inches in diameter are considerably less subject to windthrow than those larger. On the Eccles Lumber Company area 7 per cent of the 12-inch trees fell and 40 per cent of the over 30-inch diameter trees—the per cent of fall increasing with size. Much of the falling and breaking in the smaller diameters is due to the falling of big adjacent trees, rather than directly to the wind itself. On a 40-acre sample plot data were gathered on all yellow pines 4 inches to 12 inches d. b. h., as well as on the larger trees. Of the 165 trees under 12 inches left after logging, only four were windthrown, and of these four, three were destroyed by larger windthrown trees and one stood on a rocky ridge in soil only 6 inches deep.

2. The danger of windfall increases with height; of the trees over 110 feet tall on one 40-acre tract, 50 per cent were windthrown. Any tree more than 100 feet tall is a poor risk. Reserved trees most subject to windfall are those taller than the average height of the crown cover of reserved trees—*i. e.*, that extend above the general cover.

3. Trees with dense or mediumly dense crowns are particularly subject to windthrow. Trees with open foliaged crowns, regardless of size, are much less liable to be blown over.

4. The character of the trunk of the trees has very little effect upon their windfirmness; most of the trees reserved in Forest Service timber sales are sound, and one class of trunk withstands the wind about as well as another.

5. Contrary to expectation, the windfall is apparently as great on medium and deep soils as on shallow soils, other things being equal.

6. In groups of five or more trees there is considerably more windfall than where the trees are evenly distributed. Where there are sixteen or more trees in a group, the loss is 13.4 per cent greater than where the groups are smaller. A good deal of the loss in groups comes from firm trees being knocked over or broken off by windthrown neighbors or by their root anchorage being weakened by the uprooting of adjacent trees.

This is on the principle that groups of trees do not give mutual support, but do give mutual resistance to the wind.

7. On 566 acres of virgin timber adjoining the Eccles Lumber Company cut-over area there was but one yellow pine windthrown on each 5 acres, while on the cut-over land itself there was an average of one tree per acre thrown, showing that the windfall in the green timber was not excessive. It is interesting that on the windward edge of the virgin timber on a strip 5 chains wide there was an average of 1.3 windfalls per acre, and this was not uniformly along the strip, but confined principally to very local areas where as high as 100 per cent of the trees were thrown.

8. Local topography apparently does not have a very marked influence on liability to windthrow. Windfall occurs indiscriminately without regard to slope or exposure, but is slightly more severe on ridge tops and on *lee* slopes than elsewhere.

At the time of these two especially disastrous high winds the weather records for Baker, Oregon, showed a maximum velocity of 36 and of 42 miles per hour, respectively. Winds of this intensity are of more than annual occurrence in Baker, so that it cannot be said that these two gales were unsual. In the last 20 years the wind has attained a velocity of over 30 miles an hour on 61 occasions. Under like conditions, therefore, a loss by high wind, such as occurred in 1913 or in 1914 on the Eccles Lumber Company area, is liable to occur any year.

It must be remembered that this information was collected in a single locality, and that in other timber sales in yellow pine throughout Oregon and Washington the loss by windfall has not been excessive. Whether the Eccles area is topographically such that it is subject to very high winds or whether its timber is especially susceptible is not known. Neither is it known why the loss was four or five times greater on the Eccles Lumber Company sale area than on the nearby Baker White Pine Lumber Company area. But it is known that in localities like the Eccles Lumber Company area, evidently subject to windfall, the method of marking must be adjusted so that this great loss will not be suffered. This probably means that the marking must be very much heavier on risky areas than it is at present, so that no tree of a size liable to windthrow will be reserved. This will, of course, revolutionize the present theoretical scheme of management for yellow-pine stands in some localities, and the method of marking, and have some economic influence in the appraisal of yellow-pine stumpage. The problem, however, seems to be local, and until more widespread evidence of loss from windfall is available no district-wide changes in methods of marking is proposed.

SOME USES OF METEOROLOGICAL STUDIES IN SILVICULTURAL AND MANAGEMENT PROBLEMS

BY W. H. KENETY

Contributed

Forests are classified into types. The term type is applied to an area characterized by trees which are different from the trees on some other area. These trees are often styled the dominant species of the type. The anatomical characteristics which peculiarly fit them for these situations should be understood, and the response of each to the meteorological factors must be worked out definitely, in order to properly carry on silvical work to the best advantage and to interpret the now existing types.

The types present on the Cloquet Experiment Station may be classified as jack pine, Norway, white, and swamp. These may be further subdivided into subtypes. The chief meteorological factors influencing types are water, light, humidity, evaporation, aeration, and temperature. Extremes of these factors, whereby a deficit or superabundance will interfere with the normal activities of each of these species, in each of the types must be determined, and then the composite effect of the different combinations of these factors must be determined before any sure conclusion can be drawn which will not always be open to dispute. The tree itself must be the interpreter of its habitat, and its behavior in respect to these various factors must be given precedence over the theories or prejudices of the human mind.

Correlating forest types with any particular factor is very difficult, due to the fact that there is no unanimity of opinion as to the factors which are of the greatest importance in determining and controlling plant distribution. Various factors are very important only when they approach the limit of favorable conditions. This makes it necessary to determine, first of all, the limit of favorable conditions, and then how far the various factors controlling the forest type or species vary from this limit.

Quantitative differences are of very little use, because a small difference in one factor, where it is near the limit of favorable conditions, will have much greater influence than a difference twice as great in some other factor which does not approach the limit of unfavorable conditions.

Studies of meteorological factors and their influence upon types have been carried on for three years at the Cloquet Station. Some of the results obtained are given under the following heads:

Air Temperature

Very little difference was found in the temperature of the air in different types, the greatest variation being not over two degrees.

As all of the native species are acclimated, the extremes of temperature are only of great importance in connection with introduced species, and the small difference in the temperature of the air, as shown here, can have no influence on the types of forests now present.

Soil Temperature

Temperature of the soil cannot be absolutely determined until a series of thermometers are distributed throughout a type and the averages of them are determined. Until the variation in temperature of the soil in the situation itself is determined and variations in each type compared with the difference in soil temperatures between different types, it is not feasible to draw the conclusion that the difference in the types is attributable to a difference in the temperature of the soil.

Readings have been taken throughout the growing season in each type for three years, and while the differences in the type are fairly constant, the fluctuations in the types themselves are quite pronounced. Quite interesting data have been obtained which show that the swamp type of forest does not reach a temperature above 32° F. until June. This cuts short the growing season in this type as compared with the white-pine and jack-pine types, and probably accounts in a measure for the slow growth of black spruces and tamarack, which are characteristics of this type.

Soil Moisture

The water content of the soil has been correlated with types in some instances. As is now generally admitted in all studies on soils, a mere statement of the total soil moisture is of no value unless the physical and chemical analyses of the soil are known. "Data in the form of percentages of total water are usually meaningless to others, and often entirely misleading to him who made the moisture determinations."[1] The only usable data on soil moisture are some which give a standard to compare other soils with and which show the amount of moisture which is available for tree growth. The only usable standard which we have

[1] Alway: Research Bulletin 3, University of Nebraska.

found is that known as the moisture equivalent. The moisture equivalent of the soil, as described in Bulletin 45, Bureau of Soils, "represents the moisture content which soils must have in order to make it equally difficult to remove a very small additional amount of moisture from any of the soils. It is from this point of view that the determination of the moisture equivalent becomes of special importance in the comparison of moisture content of different soils under growing trees."

Shantz and Briggs have proven that the ability of different plants under favorable conditions to get water out of the soil is about equal.[2] This is further substantiated by Heinrich, who concludes that "neither the different cultivated plants nor those designated as swamp and sand plaints differ in their ability to extract water from the soil."[3]

This being true, the soil must be the main factor in determining types, because, as shown above, air temperatures vary so slightly in sharply defined types that they cannot be a means of determining types. By soil is meant its temperature, salts, texture, moisture, etc., which bear directly upon the growth of trees. Now, since the moisture equivalent of the soil gives us a standard with which to compare soils, it is evident that the moisure equivalent of the soil can be used at any time of the year under different circumstances for comparison of different types, whereas total soil moisture varies from day to day and from month to month. For instance, during the year of 1913 total moisture determinations were made in three types every day throughout the growing season, and the moisture in the jack-pine types varied in the first foot from 11.6 to 4.2 per cent in the month of July, and during the same month in the white-pine types the variations in the total soil moisture in the first foot from 14.7 to 6.3 per cent. These differences show that unless all samples were taken at the same time no logical comparison could be made between the different types on the basis of total soil moisture.

In any large area comprising 25,000 to 50,000 acres, it is an impossibility to select soil samples of the different types at periods when conditions will be the same throughout the whole region. Therefore the use of total soil moisture as a basis of determining types must be abandoned.

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[2] The wilting coefficient for different plants and its indirect determination. Bulletin 230, B. P. I.

[3] Heinrich, R.: Die Absorptionsfahigheit der Bodenarten fur Wasserdampf und deren Bedeutung fur die Pflanzen. Landwirtschafliche Annalen des mechlenburgischen patriotischen Vereins, Neueste Folge, vol. 15, 1876, pp. 353-358 and 361-363, as abstracted in Biedermann's Centralblatt fur Agrikulturchemie, vol. 12, 1877, p. 16.

Sweiter Bericht uber die Verhaltnisse und Wirksamkeit der landwirth schaftlichen Versuchs-Station zu Rostock, 1894, p. 29 (as quoted by Alway in Research Bulletin 3, p. 11, on the relation of non-available to hygroscopic coefficient).

The application of moisture-equivalent basis for determining the types of soil can perhaps be illustrated by using northern Minnesota as an illustration.

Suppose that a man has the management of 50,000 acres of land in northern Minnesota, where its cut-over and burned-over areas, as well as the areas grown up to brush, are occupied by some temporary type such as jack pine or popple. These areas must be planted in most cases, because a large percentage of the timber has been cut off and only isolated patches left to restock the land. Whatever reproduction was on the areas has in most cases been destroyed by fires which swept over the country before the land was protected. In order to plant these lands intelligently, it is necessary that the land be typed, and some standard must be used to determine the type. The native vegetation is out of the question, because so many areas which are white or Norway pine are now filled up by jack pine or popple, due to the fact that these species are much better fitted to first perpetuate themselves in the conditions which have wiped out more desirable species.

The only thing we have left to work with in these areas is the soil, and some standard of comparing the soil in these areas is necessary. After trying several methods, the one most usable to our point of view is the determination of the moisture equivalent of the soil, and the method of using it is as follows:

Some areas can usually be found where the permanent types are quite clearly defined. These will be areas where virgin stands are still present and show where different species have made the best development. These stands can be judged from density, growth, quality, etc., using stem analyses, volume tables, and other data as may be necessary to determine the best development for the species or type. In these areas enough soil samples should be selected so as to make composite samples of the soil at different depths which will be representative. The samples should be taken down to 5 feet. The moisture equivalent of these samples should be determined. This will give a standard to compare the soil of any other areas with.

When the moisture equivalent of the soils of the different types has been determined, it is only necessary to determine the moisture equivalent of the areas in question and compare it with the moisture equivalent of the soils of the different types, and then find the type of soil to which it is most closely allied. Once a standard has been obtained for the different types in a region, the work can be carried on from year to year in all parts where climatic conditions are such as to have no limiting influence upon the range of the species.

In mountainous regions the range of the different species must be known, and then the types within these ranges can be studied and determined in the same way.

The application of this method to our region is quite obvious. If a burned-over area, an area grown up to brush, or an area supporting a stand of jack pine is to be planted up, the thing to do is to take the composite samples of the soil of this area at different depths, determine the moisture equivalent of the same, and compare this with the standard already determined of the different types. Comparison will show the particular species or type to which this soil is adapted, and planting can be carried on accordingly. It is quite important that in all of our silvicultural work the right species be planted in the right place and on land which, although occupied by some temporary type and which from its present stand might seem to be jack pine, would, under this method, show its real type and would be reforested by white pine, to which it is best adapted. The same thing applies to Norway pine, popple, etc.

Over 300 samples of soil of the Cloquet Experiment Station, which comprises nearly 3,000 acres, have been taken and the moisture equivalent of each sample determined by the Department of Soils of the Minnesota Experiment Station. The averages of these determinations for the types on the Cloquet Experiment Station are as follows:

	First, feet.	Second, feet.	Third, feet.	Fourth, feet.
Jack pine	8.5	4.7	2.9	2.2
Norway pine	9.1	5.2	3.6	2.9
White pine	14.3	6.7	5.6	3.4

These figures show the moisture equivalent of the soil of these three types in this part of the country, where the rainfall and weather conditions are the same, and afford a standard for comparing any other piece of ground in this region which we wish to type and manage. It is immaterial whether the samples we gather subsequently are saturated or dried out or whether we take them this year or next, so far as the accuracy of the determinations are concerned.

The usability of this method, and the fact that the more data secured the greater the value of the results obtained, would, I think, recommend its use for all areas where there is any question as to what species the soil is best adapted to, either in a stand where natural reproduction is desired of the most desirable species or where a barren area is to be planted up.

FOREST RANGER EDUCATION

BY DORR SKEELS

Delivered before the Society February 11, 1915

What a ranger school should be must be determined first by what a forest ranger should be.

The ranger school in an eastern forest region which is training men for useful work in eastern forests, whether as ranger, guard, fire patrolman, woods foreman, or the superintendent of an estate, is filling an entirely different need than the western school which is training men for the public-service work of the forest ranger of National Forests.

My conception of a forest ranger in the National Forest Service is a man whose training should be so thorough and broad as to equip him for any of the work for which the eastern school trains rangers, as well as to equip him for work of a more difficult and responsible nature, which lies entirely without the province of the eastern school, because the work of a Government forest ranger is a public service of national scope.

In the old days of the Forest Service four grades of rangers were recognized, ranging in authority and rank from the temporary position of forest guard up through the positions of assistant forest ranger and deputy forest ranger to the higher position of a forest ranger.

The official description given in the early days by the Forest Service of rangers of various grades and the qualifications which the Forest Service sought to discover in these men conflicted curiously with the requirements which were made for their entrance into civil-service employment.

[1] It was said that a ranger of any grade must be thoroughly sound and able-bodied, capable of enduring hardships and of performing severe labor under trying conditions. He must be able to take care of himself and his horses in regions remote from settlements and supplies. He must be able to build trails and cabins, ride, pack, and deal tactfully with all classes of people. He must know something of land surveying, estimating and scaling timber, logging, land laws, mining, and the livestock business. On some Forests he needed also to be a specialist in one or more of these lines of work. Thorough familiarity with the region in which he sought employment, including its geography and its forest and

[1] The Use Book.

industrial conditions, was usually required, although lack of this might be supplied by experience in similar regions.

Experience, *not book education*,[2] was sought, although ability to make simple maps and write intelligent reports upon ordinary Forest business was essential.

Rangers were expected to execute the work of the National Forests under the direction of the supervisor. Their duties included patrol to prevent fire and trespass, estimating, surveying, marking timber, the supervision of cuttings, and similar work. They issued minor permits, looked after grazing business, investigated claims, reported on applications, and arrested for violations of Forest laws and regulations.

Forest rangers might act as assistants to the supervisor. They might be given charge of the field-work of any portion of a Forest to which the supervisor was unable to give adequate personal supervision or of the whole Forest during periods when press of office work prevented the supervisor from taking the field. No ranger was authorized to hire assistants himself except in case of fire.

Deputy rangers and assistant rangers had charge of definite districts, to which they were assigned by the supervisor. They had supervision of forest guards stationed within their districts and might be promoted to rangers.

Surely these were duties and responsibilities enough to load upon a man about to be intrusted with the administration of an important public service and to be held for promotion to higher positions, and whose examination for fitness required for civil-service entrance was so simple that a lumberjack or cow puncher could be taken from a near-by camp and coached in six evenings after office hours by a clever supervisor or forest assistant to almost perfect points of entrance.

When the ranks were thus recruited, can we wonder that criticism was made of the Forest Service that its overhead organization for administration and supervision was top-heavy; that to get a dollar's worth of work done in the field required also the expenditure of an additional dollar in the office; that of the few cents per acre spent for fire protection in a district only about one-half was for actual field-work?

The old official description of the forest ranger's necessary abilities we know now was redundant and overdrawn. That formidable array of accomplishments was required, but never secured, at a time when the Forest Service was undecided as to what it was about to do and without certain knowledge as to the way in which it was to be of great public service.

[2] The emphasis is mine.

Now, when it may be said that the Forest Service has found itself and has entered into real, well-planned, well-directed service to the nation, it is handicapped by a rank and file of men measured and selected to a considerable extent by early standards, which did not even then properly gauge them for the work which it was wrongfully assumed they would have to do.

The forest ranger is now an important official of the Service. He has charge of a district, the extent and importance of which would be a responsibility and source of pride to the Ober Forester of a German State.

He is not a drawer of water and hewer of wood, but rather an important official, intrusted with the business of organizing and operating a Forest district. He is intrusted with the care and protection of valuable resources. He directs the work of subordinates and employs and pays wages to labor. The welfare and content of individuals and families, and even of entire communities or villages or towns, depend upon his judgment, ability, and integrity. He must transact business and meet on a level with men of ability and education and culture. He has to do with the management of land and must be able to make surveys and construct maps and to read them and use them. He has to do particularly with timber and must understand wood and its uses and values. He must know how to determine the methods and costs of production. While attending to the harvest of the present crop, he must look to the continuity of a future supply. His work is by no means merely that of administration, and is, in no little part, silvicultural.

Unless for every dollar paid to the ranger and his subordinates there be paid to overheads a nearly equal amount for supervision and direction, he must understand the basic principles of tree culture and the care and protection of woodlands and the guidance of their growth to maturity.

It would be a mistake to assume that we are just now concerned in western forestry with only the removal of our present crop. Progress today is so rapid that changes follow each other in almost bewildering succession. Where the tree stands today, it is gone tomorrow, and we must concern ourselves with producing another.

True though it is that a great important problem is the proper utilization of our present stands, we practice silviculture even with the removal of our mature timber, and when it is gone, whether by fire, clean cutting, or such silvicultural method as reserves a part of the old stand, we are immediately concerned with the problem of a future growth, and this perhaps in the same ranger district and probably in the same gulch where we are yet concerned as to how we shall remove remaining portions of the old crop.

Unless we are to put upon the ranger responsibilities for which he has no training and under which he will fail, or else make of every ranger station a boarding-house for supervisory and administrative overheads, the ranger must be trained in the work which is required of him.

We are by the point when we may complacently dally with the idea that the ranger need be only superficially trained in the practical phases of his work or that a technical training in the sciences of forestry will leave him unfit to practice the arts of forestry.

If the Forest Service is to practice forestry, as well as to merely administer the uses of a public domain, its workmen must understand the theory and practice of forestry; and now, when our problems are only becoming apparent and methods are yet to be worked out, our men on the ground must be of large, broad training and capable of original and constructive work. As much today as when the forest ranger was so fully described in The Use Book is the ranger still "given charge of the field-work of any portion of the Forest to which the supervisor is unable to give adequate supervision, or of the whole Forest during periods when press of office work prevents the supervisor from taking the field."

In my opinion, hardly less important to the Forest Service than the quality of work secured is the proper training of subordinates to assure a sufficient supply of satisfactory men as material for promotion. The fact need not be disguised, and it is but natural and to be expected, that many men yet hold important administrative or supervisory positions who are either not properly trained for their work or are otherwise unfit for the position. They cannot well be supplanted until better material is available for their replacement. For many of these positions the highly technical training of the professional forester is as unfit as the qualifications of rough and ready experience of the early type of forest ranger. Professional training does not fit a man for an administrative office, although it no more unfits him for that work than would technical training unfit the ranger to practice the works of his district. If the technically trained, professional forester practices his profession, however, he has little time for executive work and secures little experience in administrative affairs.

The work of the forest ranger is necessarily largely of an executive nature, and, if his training has been sufficient, the very nature of his work is to prepare him for administrative positions of more importance.

When overhead expenses of administration and supervision may be reduced by delegating to better-trained men on the ground larger duties and greater responsibilities, there will be no less the need for professional foresters of high technical training. Rather will a greater opportunity

be given for the thorough, efficient work of such men when the district offices, and to a considerable extent the supervisor's offices, may be relieved of present exacting need for attention to innumerable small details and the inspection and supervision of work which the man on the ground is not yet properly trained to perform.

The training of the forest ranger in the theory and principle as well as the art and method of all the primary branches of forestry will not decrease the value of the graduate school for higher training in professional forestry or limit the opportunities for usefulness of the highly trained professional forester. Instead, our large universities, with their graduate courses in technical forestry, will have a greater field of work. Technically trained graduates will find larger opportunities when the workmen who carry out their plans have a proper skill and training in their vocation. Greater results and larger accomplishments may be achieved by the professional forester when his subordinates have in themselves such skill and proficiency in their work that a larger number may work under the direction of one man without constant supervision and inspection and the retrieving of mistakes and blunders.

I believe, however, that the point may yet be fairly made that some of our great universities which attempt to give graduate courses of technical training for professional forestry do not, as a matter of fact, produce real professional foresters or men of really high technical training. This, it seems, is due principally to the lax requirements for undergraduate work as preparation or qualification for entrance. When men may enter a graduate course of professional training impartially from undergraduate courses in arts, sciences, agriculture, various branches of engineering, or even such irrelevant lines of work as literature or law, or when the only requirement for graduate entrance is a collegiate degree, it may be expected that many poorly trained and well-nigh useless men will be the result. If great eastern schools of forestry are to retain their prestige and command the business of technical training of professional foresters, they must be sincere and thorough in their methods and efforts.

As a further explanation of such laxness in professional training as may exist in the greater eastern schools may be cited the tendency in western forest regions to slight or discredit the man trained merely in technical forestry. Limited opportunity is given him to practice his profession. Real practice of forestry is left largely in the hands of men of indifferent training, who hold the more responsible positions largely because they were early in their places. Usually the man of professional training in forestry from the eastern school, when he comes into the western forest region, is put at work which requires little technical

knowledge of forestry and is really the common work of the forest ranger or more often of his subordinates, and a great proportion of the professional foresters who become thus engaged never emerge from such common work to really practice their profession.

The only plausible excuse which may be offered for a long continuance of this condition will be the plea that the man from the older eastern forest schools is not actually better trained in forestry than the man who early entered the Service with indifferent training and is now doing the responsible work or the men who are now entering the Service from the newer undergraduate schools of the West. Whenever this plea is a true one, the eastern forest school of graduate professional training is at fault.

I do not believe that great schools for the higher technical training of professional foresters could be much more advantageously located in the West than in the East. In the curricula of such schools a thorough understanding of principles is of far more importance than to merely learn methods of practice. To acquire high, specialized professional training requires first a complete education in auxiliary sciences and arts and then intense specialization, and this may be best had in great universities, with their numerous specialists, exceptional advantages of libraries, laboratories, and museums—fine atmosphere of learning and unlimited incentive to investigative work.

By this is in no way meant that professional foresters need not have woods experience. Forest schools need not send out men who, to all practical purposes, have never had experience in the woods, and even universities located in great eastern cities may find opportunity for practice work in the forests of many various regions in the vacation months.

In the West, however, is the place for great undergraduate forest schools, which shall bear the same relation to forests and forestry and lumbering and wood-using industries that a school of mines bears to mines and metallurgy and mine industries, or a school of agriculture bears to farms and the agricultural sciences and the cultivation, harvesting, and marketing of food-stuffs. Such schools will be in part industrial and give vocational training rather than high professional training.

The interest of the great eastern graduate schools of forestry should be secured by the western undergraduate schools, for from them and from the ranks of their graduates in the practice of western forestry may be recruited splendid students, who have had a proper undergraduate training, have completed the apprentice period, and are prepared to receive a real professional training.

To be completely useful, a western school which bears such relations must have two broad departments of training, one of which is a department in which a training is given in the arts, sciences, and principles of fundamental branches of forestry practice; in other words, a ranger school. Its other department would concern itself chiefly with lumbering, involving many of the principles of forestry, but treating more extensively of the technics of wood, wood uses, and all the other branches of forest utilization, including logging and the manufacture and marketing of lumber and other wood products, and training to a much higher degree than the ranger school in various branches of engineering.

If the ranger school is to take inexperienced men and make of them what we need and would have in our forest ranger, four years of training are necessary, and with that the student must come to the school with a high-school training or its equivalent. Four years of time prove short enough to train a man in the principles of forestry and give him ability for practical work.

No more perplexing problem can be offered the teacher than to arrange thorough training in basic theories and principles with field study and practice work, and I believe no greater error can be made in training the ranger than to try to make of him a mere craftsman. Practice in the actual work is not nearly so important as solid training in the principles of forestry. It would be a mistake to have students spend hours of their class time in building a trail which they may learn later to build as well in no greater time when they are actually in the work. Education time should rather be devoted to training the student in principles which he could not otherwise acquire or which would be had only imperfectly and very slowly from mere practice in the work itself. Filibert Roth once expressed this clearly when he said we "must choose between mere learning of methods or a thorough understanding of principles," and that it is better to "train to think and work out problems rather than to have pupils memorize facts and fixed methods."

Early forest schools were unfortunate because their trail had not been blazed. It was uncertain then what forestry would be in America or what American foresters were doing or what they would have to do. Today past performances in American forestry may be reviewed, and thus may be foreseen quite clearly what foresters will be called upon to do at least in the near future. We may now at least always keep our ideas far enough advanced to make the necessary changes before the altered conditions are reached. More than any other school of forestry, the success of the ranger school will depend upon the close knowledge of those in charge of the school of the conditions in the regions which the school

is to serve and of the services which its rangers will be called upon to give.

In arranging the curriculum of a ranger school it must be borne in mind that general education must be given as well as vocational training. Men of advanced years or who have passed the age for education cannot be persuaded to attend a school of thorough training. The students who will come have their education not entirely completed. In order that so much as possible of the courses of instruction may be devoted to the science and art of forestry and to training for the work of the ranger, it is important that they come to the school with preparatory education such as is afforded by a good high school.

In the first years of the curriculum must be given much of the training ordinarily classified as cultural, such as English, composition, mathematics, economics, history, and perhaps a language. The auxiliary sciences must, of course, be taught, including such as biology, zoölogy and entomology, geology, physics, and chemistry. Botany must be set apart for a more thorough teaching as a part of silviculture, and I would carry as one line of study through the entire four years the various branches of botany and silviculture.

Fire protection should be treated as a part of forest administration, as may also be grazing. I would have forest administration run as a course of study through all four years, beginning with its economics, giving the prospective ranger a fine conception of his duties as the administrator of a public service, training him well in the administration of all Forest uses, the various duties of the ranger and their methods, the business of organization and operation, and the principles of management. Parallel with these lines of study, I would give through four years a series of studies in utilization, relating solely to wood, from the properties of wood through all forms of logging, manufacture, and the like, to the marketing of wood products. Again, parallel to these should run four years of the works of surveying and civil, mechanical, and structural engineering, drawing, map-making, considerable mathematics, shop practice, and the like. Forest mensuration in all its details, considerable work in lumber grading and mill studies, and particularly thorough work in scaling and cruising and forest appraisals require four years for proper completion. When a little applied mechanics and some study of motive powers is added to this list, little room is left where we would like to give a little more training in English literature and composition, a little live-stock husbandry and agriculture, more soils, a little more physics and chemistry, and engineering, but cannot for lack of more time than four years.

The student in the ranger school is carrying eighteen to twenty credit hours of work when other schools and departments of the university require but fifteen and sixteen hours. Much of his time, too, is in field, laboratory, and mill and shop work, where three hours of actual time count only one credit hour. Yet our ranger is by no means overtrained. He is far from being a technical forester, but has a good, thorough working knowledge of the fundamental principles of forestry. Rather better than that, he is trained to work intelligently and with understanding and to satisfactorily perform the business of a ranger. He is material for advancement and promotion. His very education and training give him an interest in his work, steadfastness of purpose, and loyalty to the profession of forestry and to the Service in which he is enrolled.

It was questioned for some time if suitable material would come into a forest school for four years of education and training in the work of a forest ranger. We know now certainly that it will. In order to secure men in the Service who have only ordinary ability to transact the responsible work of the forest ranger, even with no requirements as to education and training, it has been necessary to pay practically the same salary as for professional foresters in the Service of the rank of forest examiners, and involves as many responsibilities. With the improvement of ranger stations and of means of transportation and communication, the ranger is able to spend as much or more time with his family than the forest assistant, and in many cases more than the forest supervisor or even members of the district office or of the Forester's office.

If properly trained in the ranger school, his opportunities for advancement depend only upon his native ability, personality, initiative, and force of character.

An entirely different thing is the short course in forestry or winter school for forest rangers offered in several of our western forest schools. It is unfortunate that we gave to this special course of training the name of ranger school at a time when our western colleges did not offer regular courses in forestry and the real ranger schools which offered four years of undergraduate training had not yet been developed.

These short courses fill a real need in the Forest Service. In the ranks of forest officers are many men of splendid natural ability and of considerable elementary education, much experience in their work, and an intense loyalty to the Service. Many of these men have been able through carefully arranged courses of reading and through their contact with the professional foresters of the Service to gain a considerable knowledge of the principles of forestry. The experience and knowledge gained by such men in the practice of their work cannot be easily replaced, and

the natural alternative is to endeavor to complete their training at least to such an extent as will give them a fair efficiency in the ordinary routine of their work.

Such short courses were at first usually limited to six or eight weeks. In some of the schools their length has been extended from year to year, and in the school of which I am director we offer this year fourteen weeks of training for forest rangers. The ranger comes to such a short course with considerable difficulty. It costs him not only the expenses of college work for fourteen weeks, but also his loss of salary for that time. In this case it is especially necessary that his teachers should know exactly what he needs and just how to teach it to him. The teaching force should be composed almost entirely of men of long experience in National Forest work and of certain ability themselves in such work. The training must be principally in methods and in the application of principles to practice. The ranger must be directed to much reference work and every effort made to have him establish for himself the fundamental principles by further reading and studying when he returns to his ranger district.

Some of our rangers have returned to these special courses to take a second and more advanced course, and this winter some men will return for second and third courses of study.

In this paper I have frankly stated my own opinions. Although I have had some experience in National Forest work and in developing and training forest rangers, I have to admit almost entire lack of experience in regular teaching work. It may be that as I shall develop my own ideas of what a ranger school should be, I shall discover many mistakes, and I shall not be dismayed when this occurs.

The success of a four-year course of training for forest rangers seems already assured. We shall endeavor to give the training which is really needed at this time, changing our curriculum as conditions alter, and we shall only train as many men as there is need for in rangers' work.

Above all, we shall not attempt to fit unpracticed material for the work of forest rangers in less than four years of training, nor to encourage any student to secure less than four years of training, unless he already has considerable training in the way of practical experience and a record of fairly satisfactory service in the unskilled lines of forest work.

DISCUSSION

By Philip T. Coolidge

The problem of improvement of the ranger force raises the question whether it is intended to (1) replace present rangers by men with technical (ranger) training or (2) to improve the present force.

Replacement of the present force by men with more technical training would be accomplished by such a course as outlined by Skeels. Instruction of this character might well receive the attention of schools of forestry which are now giving inferior instruction in technical forestry. My feeling is, however, that the immediate needs pertaining to the personnel doing work of ranger grade, whether on public or private forests, would be met more effectively by short courses for men of proven ability in woods work than by long courses training new men.

In connection with ranger instruction generally I should like to emphasize four points:

1. In soliciting students great care should be exercised in stating the field of employment. The National Forests are such a field, but in many regions, even where lumbering is important, the prospective student cannot fairly be led to believe that there are positions in the ordinary sense.

From another point of view, the best results for all concerned are reached by definite arrangement to meet the needs of the employer. The ranger school should not be perverted into an attempt to force men with a knowledge of forestry upon employers. The arrangement between the Pennsylvania Forest Academy and the State forest administration is a striking example of instruction intended to serve as preparation for particular employment.

2. I should prefer that the candidates for ranger instruction should have had some woods experience, or that students should be required, as part of the course, to secure some woods experience away from the school. This seems to be the best method of weeding out unsuitable men, and it is undoubtedly the duty of ranger schools which train green men to do a certain amount of weeding. The demands of the public may hamper such requirements in State institutions.

3. There should be a minimum of work of an apprenticeship character, and, if any, it should be paid for. In general, training in ordinary woods labor can be secured much more easily under employment outside of a school, and employment of this kind is apt to interfere greatly with classroom work. The conditions under which ordinary woods work can be carried on at a school are not typical of conditions outside, and are there-

fore without educational value. The ranger school should be a school, not a shop. An abundance of laboratory work, in the field as well as in the class-room, rather than apprenticeship, best meets the needs of the course.

4. The length of course depends upon the class of students to be taught and upon the field of employment. As the men suitable for ranger work are usually poor, courses, in general, should be short; but it is inadvisable to attempt to formulate much more definitely what the length of course should be.

For men under employment three or four months is the maximum that they should be expected to afford and is generally more than they can afford. The Pennsylvania course of three years is, on the other hand, satisfactory, I believe, probably because students are assured of employment. The four-year course which Mr. Skeels outlines, however, is only one year shorter than courses in many schools of technical forestry, completion of which gives graduates full standing in a profession recognized as scientific. Men who can afford to take long courses are apt to have tastes which do not fit them for continued ranger work. The real need of ranger instruction is to teach every-day forestry to men who will stay in the woods.

As to instruction, the average technically trained forester is apt to spend too much time upon botany and similar purely scientific subjects. It is surprising to find how little instruction of this kind is really necessary and how quickly the interest of students in it flags.

The ideal instructor in a ranger school should have had, in addition to technical training in forestry, considerable practical experience in forest administration or lumbering, depending upon the field of employment to be supplied.

By W. D. Sterrett

As a result of Mr. Skeels' paper and the discussion which followed, the following summary of suggestions is offered for a possible Federal Forest Service attitude on the subject of ranger education:

1. The Forest Service desires to obtain the best equipped men in ranger positions.

2. Rangers can only be considered *completely* equipped who have gone through some such school (or its equivalent) as outlined by Skeels, which, of course, prepares the man also for other jobs. Name for such a school not important. It is, however, important to get men whose knowledge and training is of the broadest kind, as such men will be able to grow as fast as the Forest Service grows in adopting intensive methods.

3. At present it is probable that only a small per cent of such graduates would become rangers.

4. The proposition is, then, for the Forest Service to encourage an increase in the number and capacity of such schools, so as to have a larger number of possibilities to draw on.

5. It is out of the question that such schools could be run as administrative work of the Federal Government, as the State of Pennsylvania does at Mont Alto.

6. Education of rangers from a Forest Service administrative standpoint will have to be confined to: (1) correspondence courses and personal instruction in the field by forest experts; (2) encouragement to them to go to regular schools for short intervals (by holding their jobs open), with the idea of their finally fully qualifying (technically) by graduation. Proper credit, of course, should be given them in the schools for their training and experience and private studies in forestry, which would greatly cut down the time they would need to spend in schools.

7. As the number of such schools and its graduates increase, ranger education, as administrative work, would diminish, although it should, of course, never entirely disappear, as it is full of good possibilities, even for a well-educated body of rangers.

8. As Coolidge says, a one-year ranger's course, such as given in New York, is a waste of time and money for the man taking it. If it were a purely administrative proposition of increasing the knowledge of men already selected by the State for rangers, it would be a different matter: but as it is, it is impossible to properly equip a young man in one year in the vocation (if there is such a thing) of ranger so as to make him eligible to any ranger job which may come along. Three or four years is absolutely necessary for training the young man for the general vocation of ranger, and it is not fair to him to advertise short cuts to this end in the guise of one-month or one-year courses in forestry. On these grounds it might be proper for the Forest Service to discourage entirely one-year ranger schools.

THE REFORESTATION OF BRUSH FIELDS IN NORTHERN CALIFORNIA

BY RICHARD H. BOERKER

Contributed

One of the greatest silvicultural problems which confronts the Forest Service in California is the reforestation of the vast brush fields in the central and northern part of the State. Rough estimates place the total area so occupied at 2,000,000 acres. This area, instead of producing timber worth from $30 to $50 per acre, is occupied by brush of little value, even as browse. Moreover, with such an enormous area of potential forest land lying unproductive, the State has a problem not only of great importance to itself, but one of great economic importance to the nation.

Unlike the chaparral regions of southern California, this brush is only a temporary type, and is, in most cases, the result of fire having destroyed the forest cover. In the days before the Forest Service system of protection was maintained, fire, originating in various ways, swept through the timber unmolested. Not a small part of our brush areas may be attributed to "light-burning,"[1] which was practiced for many years by Indians, and more recently by stockmen. In most cases, in from 5 to 10 years after the fire has consumed the timber, the brush takes possession of the land, the length of time depending upon the severity of the fire, the presence of brush plants in or near the fire area, and other conditions. After the brush has established itself, if seed trees are near by, seedlings will get started and fight their way through the brush. It takes from 15 to 30 years for a seedling to get large enough to overtop the brush, this depending upon the height of the brush, the tree species, and other factors. This is usually an intense struggle, and even if a sapling has succeeded in winning out, it is of small size as compared to forest-grown trees of the same age. In course of time, if the stand of saplings becomes dense enough, the brush underneath will be killed on account of lack of sunlight, and a forest cover will begin to form. This is Nature's very slow process of reëstablishing a forest cover. If there are no seed trees

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[1] The methods and results of light-burning are described in detail in an article, "Light-burning versus Forest Management." Forestry Quarterly, vol. X, No. 2.

near the burned area, it is only a matter for conjecture how long it will take a forest to reëstablish itself.

One of the important lines of investigation which the Forest Service has undertaken is to assist nature in reclaiming these useless areas. Planting has been resorted to in favorable localities, where the absence of seed trees makes the process of natural regeneration an extremely slow one. It is the purpose of this paper to describe an apparently successful operation in reforesting a brush area of this kind.

The Lassen National Forest has about 150,000 acres of this brush land, and some of it can be seen from the top of any mountain one may choose to climb. The individual areas vary in size from small patches to areas covering as much as half a township. The species are mostly evergreen xerophytes, and many of them, or at least close relatives, may be found in the well-known chaparral regions of southern California. A list of the more important species in the order of their abundance follows:

1. Arctostaphylos glauca—great berried manzanita.
2. Arctostaphylos manzanita—common manzanita.
3. Ceanothus velutinus—snowbush.
4. Ceanothus cordulatus—white-thorn.
5. Amelanchier alnifolia—service berry.
6. Ceanothus integerrimus—blue brush.
7. Castanopsis chrysophylla minor—chinquapin.
8. Prunus demissa—choke cherry.
9. Prunus emarginata—bitter cherry.
10. Cercocarpus ledifolius—curl-leaf mahogany.
11. Cercocarpus parvifolius—birch-leaf mahogany.
12. Ceanothus prostratus—squaw carpet.
13. Uva-ursi paluta—dwarf manzanita.

With the exception of the large sage-brush areas, these species constitute approximately 95 per cent of the brush areas referred to in this article. The three most important species which make up most of the large areas and the per cent which they represent in these areas are:

	Per cent.
Manzanita species	60
Snowbush	20
White-thorn	5
All others	15
Total	100

Besides the species enumerated above, there are from 40 to 50 others, which, however, are of minor importance in reforestation.

Next to the matter of abundance, the most important consideration is

tolerance. With the idea of tolerance are coupled the ideas of density of foliage, ability for man to penetrate it, amount of direct and diffused light admitted to the seedling underneath, and the possibility of allowing young trees to start under it and penetrate through it. Such species as manzanita, snowbush, and cherry are less tolerant than white-thorn, chinquapin, and service berry, and hence are more favorable in every respect for planting purposes.

VALUE OF THE CHAPARRAL TYPE

In addition to being only a temporary type, the chaparral is a transitional type between timberland that has been swept bare by fire and timberland that is actually producing timber. This type seems to be an intermediate stage through which most of our timberlands which have been swept bare by fire must pass before they can again revert to timberland. There are many reasons why the forest will not take direct possession. When fire has finished its work there is usually nothing left but the bare mineral soil; even this has suffered severely from the heat. The soil has lost its humous condition and its fertility. The valuable nitrogen has gone off in the smoke, and has left the less valuable mineral elements. In addition to this, the light, shallow, volcanic soils are left to the mercy of their worst enemies, drought and erosion. Our long dry season deprives these soils of every vestige of moisture, and if it were not for the brush our heavy rains and snows and high winds would soon transport most of these soils, leaving nothing but the bare rocks. To wait for the forest to slowly take hold of these burned-over areas would be to expose our soils to all these conditions for many years before there would be a stand dense enough to protect the site. The so-called brush species are the only plants that can endure these adverse conditions, so that in establishing themselves on these burned areas they perform a most valuable silvicultural function. They not only prevent the soil from being transported, but they also put the soil into a condition so that it can again produce timber. Brush, besides enriching the soil with decaying leaves, forms temporary forest conditions for the young seedling. The humus, which is formed from the yearly fall of leaves from the brush, due to its hygroscopic character increases the water-holding capacity of the soil. Humus also acts like a cultivator, in that it keeps the soil loose and flocculated, and for this reason, too, the soil will hold more water. The litter and leaves from the brush, and the brush itself, form a cover for the soil which prevents evaporation. In consequence, not only does the soil gain more water, but it loses less. This is very important on account of the long dry season. Brush affords the young

seedling a certain amount of shade, which, while of minor importance to the moisture element, may be likened to the shade of the mother trees in the forest, which prevents excessive transpiration through the leaves.

SITE CONSIDERATIONS IN PLANTING

Before going into the details of the work a brief discussion of the site conditions under which this planting must be done may be in order. Especially is the discussion of climate important to show why fall planting is necessary. The most characteristic elements of the climate of this region are:

1. A long dry season.
2. Regular fall rains.
3. Frosts during the growing season.
4. A heavy snowfall.

Of these the first two are of the greatest consequence. Only 2 per cent of the total annual rainfall occurs from June 1 to September 30: hence this period constitutes the dry season. The regular fall rains come in the latter part of October and November. Spring planting would subject the young plants to the long period of drought just at the critical period of growth; hence fall planting just preceding the rains is more desirable, and was in this case resorted to. Frosts may occur at almost any time of the year above an elevation of 5,000 feet. At the higher elevations huge snowbanks keep the soil well supplied with moisture until late into the summer.

The two factors which are apt to cause failure, both at the time of planting and subsequently, are lack of soil moisture and extreme temperatures. Of the two the former is the more important.

Of the two general slopes of the Sierras, the east and the west, the latter is from every standpoint the more favorable. On the east slope there is much danger from drought, due principally to the small amount of precipitation, high summer temperatures, and a high degree of isolation. The west slope, being in the path of the humid winds from the ocean, has a more equable climate; that is to say, neither the daily nor the seasonal extremes of temperature are as great as on the east slope. The statistics of the U. S. Weather Bureau show that for the same elevation and same latitude on both slopes there is from 10 to 25 inches more rainfall on the west slope; the mean monthly temperature for January is from 3 to 5 degrees higher and the mean monthly temperature for July is from 1 to 4 degrees lower than on the east slope. The average date of the latest killing frost is from 10 to 12 weeks earlier in the spring

on the west slope and the average date of the earliest killing frost is from 2 to 5 weeks later in the fall. This makes the average growing season about 200 days on the west slope as against only 135 on the east slope.

SELECTING PLANTING AREAS

For the purpose of this experiment in reforestation two distinct plantations were made, one on the east slope and one on the west slope of the Sierras. The seedlings were shipped from the Pilgrim Creek Nursery at McCloud, California. Regarding the site and the shipments, the following is of interest:

	EAST SLOPE AREA.	WEST SLOPE AREA.
Elevation	5,600 feet	5,000 feet.
Area	18 acres	18 acres.
Aspects	Northern and northeastern.	Northern, northwestern, western, southwestern, southern.
Soil	Fine, deep loam	Sandy loam with gravelly areas.
Density of brush	50 per cent medium	33⅓ per cent loam.
	50 per cent dense	33⅓ per cent medium.
		33⅓ per cent dense.
Stock:		
Yellow pine	13,500 (1–1)	12,500 (1–1).
Yellow pine		1,000 (1–2).
Sugar pine	1,000 (2–1)	1,500 (2–1).
Incense cedar	500 (1–1)	1,000 (1–1).
Method of shipment	Express	Freight.
Shipment by rail	131 miles	201 miles.
Hauled by team	100 miles	15 miles.
Total days en route	7 days	11½ days.

THEORY AND METHOD OF PLANTING

The theory upon which the planting work was based was that the young plants needed protection and shade after they had been planted. The soil should be shaded to reduce evaporation to a minimum, and the young trees should be shaded to prevent transpiration through the leaves. For these reasons, wherever it was possible the trees were planted on the shady side of the individual brush plant, viz.: that side which gets the least direct sunlight. Temperatures in the shade of the brush are cooler in the warm part of the day and warmer in the cold parts of the day than in the open. Evaporation of moisture from the soil is important both winter and summer; hence planting under evergreen brush is much more advantageous. Snow lies longer under the brush, and hence feeds the soil with snow-water for a longer period of time than is the case in the open places. The moisture in the soil is distributed somewhat differently in the shade of the brush than in the open. A careful investiga-

tion of the condition of the soil directly at the stool of the brush plant, and then at various distances away from the stool until one gets out on open ground, reveals the following facts: Directly in the shade of the brush plant, and especially those places that get the minimum of direct sunlight, there is first a layer of leaves, and under this a layer of humus from ½ inch to 1 inch deep. This latter layer, together with about an inch of humous soil directly underneath, comprises the soil layer of greatest water content. As one digs down, the moisture content gets less down to a depth of about 15 inches, below which the moisture content remains practically constant. In the open, away from the brush plant, there are no leaves and humus. The top layer of soil is the layer of minimum water content, drier than the driest layer in the other case. From 6 to 12 inches there is not much more moisture, and at about 20 inches there is not as much moisture as there is at 12 to 15 inches in the soil under the brush plant. This difference is more marked when contrasting the soil to the south of a brush plant with that to the north than it is when contrasting the south side with either the east or west. Not only does the soil in the shade of the brush absorb more water, but it loses less than the soil in the open. From the standpoint of soil moisture, therefore, it seems reasonable to assume that a young tree would endure our long droughts much better if it were placed in the shade of the individual brush plant.

The trees were planted about 6 feet apart each way; but this arrangement could not be strictly adhered to on account of the distribution of the individual brush plants. Holes were dug with a mattock, and behind the digger came the planter with a canvas water bucket containing seedlings. Each pail contained a few inches of water to keep the roots of the seedlings constantly moist. A small area in the shade of the brush was selected which was free from dead branches, rocks, etc., where a man could work with a mattock and where planting could be done without much preliminary work. The two crews averaged from 250 to 275 trees per man per day, but often the work was a good deal slower than this, especially in the dense brush.

WEATHER CONDITIONS AT THE TIME OF PLANTING

Weather conditions at the time of planting, in the opinion of the writer, is one of the most important factors which determines the initial success of a plantation of this kind. On the east slope the days were bright and clear. At noon the temperatures were very high, while every night the temperatures fell below the freezing point and sometimes as low as zero. In peculiar contrast to this, the weather on the west slope

was mild. The days were mostly cloudy. On one or two days it rained or snowed. The days were usually warm and the nights cool; only on one or two occasions did the thermometer reach freezing point. The incense cedar, sugar pine, the yellow pine (1-2), and about 1,000 of the yellow pine (1-1) were snowed under for six days prior to planting. Following the snowstorm the weather became very mild and the snow melted off completely. The planting work was then completed, although without doubt the trees had suffered considerably from the exposure. From this it will be seen that, except for the snowstorm, weather conditions were much more favorable on the west slope than on the east slope. Doubtless this had a considerable bearing on the success of the respective plantations; at least the plantation which was made under the unfavorable conditions did not succeed.

Costs per acre.

Species.	Cost of trees per M.	Cost per acre (860).	Cost from nursery to site.	Cost of planting.	Total.
Yellow pine........	$11.78	$10.13	$2.23	$8.89	$21.25
Sugar pine........	12.41	10.67	2.23	8.89	21.79
Incense cedar.....	20.30	17.46	2.23	8.89	28.58
Average apportioned by number of each species..................					$21.53

According to the latest data available from the nursery, the costs of raising stock have been materially reduced. By planting the accessible brush areas first, thereby reducing transportation charges, and by planting less trees per acre, the cost of establishing a plantation could, if undertaken on a commercial scale, be reduced to approximately $10 per acre.

RESULTS

Both areas were examined by the writer in July, 1914, about 21 months after the planting was done. For reasons difficult to determine, the plantation on the east slope was a total failure, less than 5 per cent surviving. The causes of this failure seem to the writer to be due, first, to the less favorable climatic conditions under which the young trees must struggle, and, secondly, to the extremes of temperatures encountered at the time of planting.

The plantation on the west slope (except the incense cedar) may be considered a success, about 73 per cent surviving. The results on the west slope, based on an actual count on representative areas of 3,346 plants by rows, are shown in the following table:

Count representative of 15,000 trees planted west slope Sierra Nevada Mountains.

Species.	Character of brush.	Aspect.	Age.	Total counted.	Number alive.	Number dead.	Per cent alive
Sugar pine.	Open brush..... Few mature trees	N	2-1	248	188	60	76
Yellow pine	Open brush..... Few trees......	N, NW	1-1	861	697	164	81
Yellow pine	Medium brush..	N, NW	1-1	415	317	98	76
Yellow pine	Medium brush..	NW, W	1-1	475	381	94	80
Yellow pine	Dense brush....	S, SW	1-1	324	196	128	60
Yellow pine	Dense brush....	W, SW	1-1	782	492	290	63
Yellow pine	Open brush..... Scattered timber	W, NW	1-2	241	170	71	70
	Total all pines..........		.....	3,346	2,441	905	73

Since each brush density class covered approximately one-third of the area, it is interesting to compare the same species and age of stock in the various parts of the area planted. The data gathered for 1-1 yellow pine, tabulated below, shows, irrespective of aspect, the per cent of living trees found in the different densities of brush:

Brush density class.	Total count.	Number alive.	Number dead.	Per cent alive.
Open brush..................	861	697	164	81
Medium brush................	890	698	192	78
Dense brush.................	1,106	688	418	62
Total..................	2,857	2,083	774	73

The conclusions to be drawn from the examination made and the recommendations for future work of this kind will be discussed under the following heads:

Soil.—On a northern aspect the yellow pines survived, regardless of whether they were on coarse granitic soil or on fine humus soil. On the southern and southwestern aspects, practically the only trees that survived on the coarse soil were in the shade of the brush; the poorer the soil the more plants were found in the shade of the brush, and, in general, the less plants were to be found on the poor aspects. Soil seems to intensify the favorable or unfavorable effects of other factors. Where other factors are unfavorable, good soil becomes important in direct proportion.

Species.—Nothing conclusive was shown in regard to the various species planted. Sugar pine seemed to do about as well as yellow pine. There seems little room for doubt that the intolerance of the pines was the principal cause for the greater per cent surviving in the open and medium brush as against the dense brush. For future work this should be taken into account: openings and open brush should be planted with pines, and the dense brush with more tolerant species, like firs and cedar.

Age of stock.—Nothing conclusive was shown in regard to age, as between the yellow pine 1-1 and the 1-2. The data collected show a smaller per cent of 1-2 surviving than 1-1, under practically the same conditions of aspect, brush, and soil.

Density of brush.—The data collected show that, as far as yellow pine 1-1 stock is concerned, the more open the brush the greater are the chances for success. Yellow pine was more successful in the open, scattered brush than in the brush of medium density, although this difference was not marked (only 3 per cent). A greater difference was manifested between the medium and the dense brush (16 per cent). In future work, either the very dense brush should be thinned out before planting or the scattered areas of open and medium brush should be planted to pine and fir, with the intention of letting the fir gradually extend into the adjacent dense brush naturally.

Aspect.—On a northern and northwestern aspect less trees survived in the very dense brush than on the western and southern aspects. On the northern and northwestern aspects more trees survived in the open brush than on the western and southern aspects. In other words, the more unfavorable the aspect the more shade seems necessary to produce success. The primary cause for this is undoubtedly difference in degree of insulation of the different aspects. Dense brush on a northern aspect is quite as unfavorable as open brush on a southern aspect, other factors being equal. The data show that the aspects for pine on the west slope, in the order of their favorableness, are: western, northwestern, northern, southwestern, southern.

Brush species.—From observations made, it seems that pines are more successful under the intolerant brush species than under the tolerant ones. The tolerant ones should be underplanted with firs and cedar.

Concerning the method of planting, little can be added except that too much emphasis cannot be laid on the finer points of planting nursery stock. There can be no doubt that planting in the shade of the brush greatly increases the chances for success. This is especially true on the poorer soils and the less favorable aspects. In these cases the shade of the brush tends to become an ameliorating factor, helping to retain the

moisture in the soil by reducing evaporation and transpiration. In the case of the intolerant pines there is, of course, a limit to the amount of shade that is beneficial. Firs and cedar would undoubtedly survive in denser shade than would pines.

While the conclusions derived from this work are by no means indisputable and final, they at least ought to lead to further and more intensive experimentation along these lines until something definite is obtained. The problem is one that deserves concentrated and intensive effort of the highest quality. In future operations it should be remembered that for experimental purposes 5 acres of plantation ought to show as much as 40 to 50 acres, and cost considerably less. For the same reason, 500 trees per acre would serve the same purpose as 1,000 or more per acre. It is highly desirable to stake all trees at the time of planting, so that a more accurate count can be made later. Successful areas should be protected from live stock and fire.

A SILVICULTURAL SYSTEM FOR WESTERN YELLOW PINE IN THE BLACK HILLS

BY P. T. SMITH

Contributed

The Black Hills of South Dakota and Wyoming occupy a peculiar position, geologically, in relation to the surrounding country. They are the result of a dome-shaped uplift in the earth's crust, which rises abruptly from the plains to an elevation of from 2,000 to 3,000 feet above the surrounding country. Isolated from other mountain ranges, they are surrounded on all sides by the broad expanses of the Great Plains. The nearest mountain range of any consequence is the Big Horn range of Wyoming, 150 miles to the west, while to the east the Ozark Mountains of Arkansas are approximately 1,000 miles distant.

The Black Hills range is 100 miles long and from 40 to 50 miles wide, extending in a northwesterly and southeasterly direction, covering approximately 4,000 square miles. The greater part of this area lies within the State of South Dakota, only a small part extending over into Wyoming.

The principal geological formation is limestone, and a high plateau of this formation along the State line between Wyoming and South Dakota, the greater part of which is in the latter State, forms the backbone of the hills. To the east of this plateau slate formations come into prominence, forming a broad band of low hills with occasional high peaks. Still farther east, beyond this belt of slate hills, is a narrow belt of limestone ridges, which forms the eastern border of the main range. In the extreme northern portion there are outcroppings of igneous rock; but these are of small importance because of their limited extent. There are, therefore, two main geological formations in the Black Hills region: the limestone formation, occupying the western half and a small portion of the eastern part, and the slate formation, occupying most of the region between these two areas of limestone. It is on these two formations that most of the timber is found, the igneous formations being of small extent and for the most part barren rock outcroppings.

From these two formations the soil of the Black Hills has been formed by the gradual erosion due to wind and water. The latter has had the greater influence, and numerous canyons have been cut into the hills.

The soil is of an alluvial origin and consequently is a fine sandy or silt loam and of a very good quality, supporting a luxuriant growth of vegetation. Where the soil can be cultivated, good crops of oats, barley, or hay are raised, indicating that the soil is very rich. The quality of timber produced is correspondingly good, and over most of the area of the Black Hills a very heavy stand of timber is found. The soil has been divided into three classes, or sites, based on the natural differences in the depth and amount of moisture normally present.

Site I embraces the bottom lands, low bench lands, and gentle north slopes, where the soil is deep and free from rocks and where there is a good supply of moisture throughout the year. This site produces the best quality of timber, the trees being tall, straight, and sound.

Site II is found above site I, usually occupying the steeper north slopes, table-lands, and parts of the east, west, and south exposures. This site has a fairly deep soil, with few rocks and a fair amount of moisture throughout most of the year. During the latter part of the summer the moisture supply may get rather scarce, except during wet years. This site produces a very good quality of timber, which does not, however, attain the height growth found on site I. It occupies by far the greater part of the area of the Forest.

Site III is the poorest in quality, occupying the ridges and dry south slopes. The soil is shallow and rock outcroppings are prominent. This site is the first to show the effect of drought. and as a result the timber is short, limby, and usually very poor in quality.

The climate of the Black Hills is very different from that of the surrounding plains. Being the only high area within a wide radius, the hills act as a condenser for all moisture which comes within their reach. Very different from the semi-arid regions around them, the Black Hills support a very luxuriant growth of vegetation. The rainfall is approximately twice as heavy as that of the surrounding prairies.

The growing season is much longer than that of most mountain regions, the spring opening up in April and the growing season continuing until October. This gives a sufficient time for the timber to put on a very good growth each year.

The Black Hills, because of their location in the center of a great prairie country, are the logical source of timber supply for a great area. These prairies are fast being settled and converted into an agricultural country, and the building up of ranches and towns will require a large amount of timber products. It is very largely from the Black Hills that this region will draw their lumber and other building materials.

The mines of the Black Hills region are another market for timber products which is being supplied entirely from the Black Hills forests. The mining industry is growing very rapidly and the demand for all classes of mining timbers is on the increase. There is one mine located in the northern part of the Black Hills which alone uses annually five million feet board measure in lumber and mining timbers.

The Burlington Railroad Company, with its demand for ties for its lines in South Dakota and Nebraska, is a third market which is very largely supplied from the forests of the Black Hills. The materials which supply this market are obtained almost entirely from thinnings in immature stands. The removal of this class of material is not only a source of revenue, but leaves the remaining stands in much better condition for growth and is a benefit to the forest.

The areas which supply these timber-using industries of the Black Hills are more or less definitely defined within the Black Hills Forest. The areas which supply the lumber industry are very largely located in the southeastern, eastern, and northern parts of the Forest, adjacent to the prairies where a large part of the materials is used. The mining-timber industry is supplied very largely from the east-central and central parts of the Forest, within easy reach of the mines where the products are used. The tie industry is supplied from the central, western, and southern parts of the Forest, in places accessible to the Burlington Railroad.

This more or less definite segregation of the areas which supply the different timber-using industries is fortunate, in that it can be used to advantage in the management of the Forests for the different purposes. The rotations for the production of the different classes of material demanded by the different industries are entirely different, and could be applied to the various parts of the Forest, managed for the particular industry for which each is intended, with greater ease than could otherwise be done.

Western yellow pine is the only species which occurs in sufficient quantities in the Black Hills to be of commercial importance. Canadian white spruce and lodgepole pine occur in small stands where conditions are favorable for their growth, but not in sufficient quantities to be of importance. Of the entire forested area of the Black Hills Forest, yellow pine occupies approximately 95 per cent. It occurs under all conditions of density, altitude, and moisture.

Two conditions of stand exist in the yellow pine of this region: even-aged stands, which have resulted very largely from fires and to some extent from logging, and mixed-aged stands in which age classes appear

in small groups intermingled with each other. These stands are very largely due to natural causes.

The former, or even-aged, stands occur throughout the central, northern, and western parts of the Forest where logging operations and fire have converted the stands almost entirely to young, relatively even-aged stands of saplings and poles. Throughout the southern and eastern parts of the Forest even-aged stands of mature and over-mature timber occur, which are undoubtedly the result of fires which occurred from 150 to 300 years ago. These even-aged stands are of the greater importance in this region, not only because of their more extensive area, but also because, due to the nature of the species, the best development in yellow pine is found in even-aged stands.

The mixed-age class stands occur very largely on areas which have never been logged over and on which no fires of very recent date have occurred. They are the result of natural causes, such as insect infestations, fungus attacks, and wind-storms which destroyed small patches of timber throughout the stand at various times. These openings have since been regenerated by seed from the surrounding stands, and new age-classes thereby formed. The mixed-age class stands occur throughout the Forest, especially in the southern and eastern parts, in connection with the even-aged stands.

Conditions for reproduction in the Black Hills are exceptionally good, as is shown by the excellent stands of reproduction found in all parts of the Forest. There is always plenty of moisture present in the soil to promote germination, and good seed years occur, on the average, every three years, while some seed is matured every year. Reproduction in this region is not the result of the accidental occurrence of a good seed year with a year of an abundance of moisture, as is the case in many yellow-pine regions, but is rather the general rule.

The ease with which reproduction is secured in the forests of the Black Hills is a fortunate condition for the forester who is called upon to manage the forests of this region. It reduces this factor—which in most yellow-pine regions is of chief importance—to a secondary place in the consideration of silvicultural systems to be employed in management plans, and allows other factors—which under other conditions would necessarily be made secondary to the reproduction factor—to be magnified and given more consideration than would otherwise be possible.

In any silvicultural system the growth and development is the next consideration to the establishing of a stand by natural reproduction. As shown above, the establishing of a stand in the Black Hills region can be accomplished under practically any silvicultural system used. The

factor of growth may, therefore, be emphasized in the silvicultural system to be used, and made the deciding factor.

Yellow pine is a very intolerant species except in the seedling stage. For this reason, to obtain the maximum-stand development it is necessary that the maximum amount of light, moisture, and heat be available for the individuals of the stand. To produce these maximum conditions it is necessary that the stand be of approximately even age where the competition between individuals of the stand is even.

The shelterwood system is the one most applicable to the development of even-aged stands. By this system a stand of reproduction is assured, and the proper amount of protection for the best development of the seedlings is provided. This shelter, which is so beneficial to yellow pine in the seedling stage, but so detrimental in the older stages of its development, is removed, in the application of this system, before it becomes a detriment to the young stand.

The shelterwood system, as applied to the even-aged stands of the Black Hills Forest, should be restricted to two cuts. The first, or seed cut, should remove from 60 to 70 per cent of the volume of the stand. The objects of this cut should be to remove the mature and over-mature trees, defective or diseased trees, whose presence are a menace to the remaining stand, and to leave the remaining stand as well distributed over the area as possible, in order that the greatest amount of protection may be furnished to the seedling stands. The second, or removal cut, should be made in from 20 to 40 years after the seed cut, when all the original stand should be removed. The time which is allowed to elapse between the first and second cuts should be governed entirely by the condition and development of the stand of reproduction. The second cut should never be made until the reproduction on the area is thoroughly established and has reached a size sufficient to make it practically immune from damage by an ordinary surface fire. This will ordinarily be from 20 to 40 years after the seed cut.

The shelterwood system is not without its faults, as applied to the stands of yellow pine in the Black Hills. The principal drawback is in the ever-present fire danger which threatens the stands of seedlings after the first cut. An attempt to offset this danger in the application of the system to this region is made by deferring the second, or removal cut, until the seedlings have reached a stage of development which will make them practically immune from danger by an ordinary surface fire.

Another factor, which removes to a large extent the above objection to the shelterwood system, is the increasing efficiency of the fire-protection system of the Black Hills Forest. With fire lookouts stationed on

commanding points over the Forest, and with a network of telephones over which the lookouts may communicate the occurrence of a fire to any forest officer on the Forest, and with fire-fighting implements located at two or three points of vantage within each township in the Forest, fires—except at very unfavorable times—never gain much headway.

Another condition brought about by the shelterwood system which is very unfavorable to the marketing of the crop, is the difficulty with which the second cut will be made. The dense stands of reproduction which come in after the original stand is opened up by the first cut will form a barrier around the remaining trees of the stand which will greatly increase the costs of logging in the second cut. This increase in the cost of logging must be offset by a smaller stumpage value than would otherwise be possible. The increase in the rate of growth of the stands, however, due to their even-aged character, will more than balance this loss due to the increased cost of logging.

In the mixed-aged stands which occur throughout the Black Hills Forest, the age classes are found in distinct groups, usually of small size and irregular shapes. To stands of this character the group selection system is most applicable. This system, as it should be applied, amounts practically to a clear cutting in groups. The even-aged groups are considered as the units, and in the application of the system each group of mature and over-mature trees will be cut clean. Other groups will be cut as they reach maturity. The groups are of all shapes, usually rather irregular, but never of very great extent. The openings made in the stand may vary in size from one-tenth of an acre to several acres, but should never exceed three chains in width at any place.

This system is not entirely applicable to the best growth conditions of yellow pine, as the groups are small and there is at all times a considerable part of the stand which is enduring more or less uneven competition. The young stands which come in after cutting are entirely surrounded by stands which are older and more advanced in growth. This places them at a decided disadvantage, as the more advanced stands have established themselves and are better able to compete for the best growth conditions than the seedling stands. This condition will result in a more or less uneven growth of the stands of reproduction resulting from the cutting, as the seedlings which occur at the outer edges of the cut-over area have more competition with the surrounding stands than those in the center of the area cut.

This system will be used as a temporary system, whereby the existing conditions in the mixed-age stands will be corrected and brought under more or less even-aged conditions. This cannot be accomplished at once,

but will be a gradual change. As soon as the even-aged conditions are established, the shelterwood system as outlined above will be applied.

In the application of these two systems to the conditions of actual timber-sale administration, a great deal of latitude must be allowed the administrative officer. The conditions are so varied, even in comparatively restricted areas, that definite rules cannot be made to apply equally well to all conditions. For this reason the marking officer should be thoroughly familiar with the requirements of the species, and should apply the above systems with such modifications as seem necessary to meet the conditions.

THE USE OF FRUSTUM FORM FACTORS IN CONSTRUCTING VOLUME TABLES FOR WESTERN YELLOW PINE IN THE SOUTHWEST [1]

BY CLARENCE F. KORSTIAN

Contributed

OBJECT

The object of this investigation was to determine the feasibility of using the frustum form factor method of constructing volume tables for western yellow pine in the Southwest, and to compare it with the conventional method as to accuracy and number of trees required for a satisfactory table.

The frustum form factor is the ratio between the volume of the merchantable stem of any tree and that of the frustum of a cone having the same height and the same upper and lower bases. The frustum form factor method was suggested by Donald Bruce.[2] The results of his subsequent check of this method for constructing volume tables for western white pine in District 1 indicate that the method is worthy of investigation. The following merits are claimed by Bruce[3] for this method:

(1) It eliminates the variation in the merchantable lengths of trees of the same d. b. h. and height classes, because a full-boled tree has a greater volume and consequently a larger frustum form factor than a more rapidly tapering tree having the same diameter and total height.

(2) The table is particularly strengthened at the weakest points, namely, the extreme values. A set of curves can be drawn showing the volume in board feet of frustums of cones having the same upper and lower bases as the averages of a tree on which the table is to be based. These will constitute a set of standard curves by which to be guided when in doubt as to the shape and position of the curves resulting from the average tree measurements.

(3) The number of measurements needed for a satisfactory and fairly accurate table is greatly reduced.

(4) Compared with the conventional method, this gives much more accurate results involving but a fraction of the expense.

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[1] The writer is indebted to Donald Bruce for a critical review of the original manuscript.

[2] Bruce, Donald, "A New Method of Constructing Volume Tables," Forestry Quarterly, Vol. X, No. 2, p. 215, 1912.

[3] Bruce, Donald, "The Use of Frustum Form Factors in Constructing Volume Tables," Proceedings of the Society of American Foresters, Vol. VIII, No. 3, pp. 278–288, 1913.

OPERATIONS

This investigation was conducted in the district office, where volume data were available for over 6,000 western yellow-pine trees.

The average top diameter to which trees of the different d. b. h. classes were cut was determined. An average of 1,000 trees gave 10.2 inches as the top diameter inside the bark. All diameter classes were represented in the same proportion as found in the original data, which were collected on the Coconino and Tusayan National Forests for the 1913 volume table for western yellow pine.

A table of frustum volumes was constructed showing the volumes in feet, b. m., when scaled by the Scribner Decimal C rule in 16-foot lengths, of frustums of cones having a top diameter of 10 inches and a bottom diameter equivalent to the d. b. h. in inches from 10 to 50 inches and heights in even 16-foot lengths up to 112 feet.

The top diameters of the different sections were calculated to the nearest 0.1 of an inch and all sections were scaled by the Scribner Decimal C rule. In this respect the writer differed from Bruce, who interpolated to the nearest board foot. This degree of interpolation is not considered consistent with actual scaling practice when using the Scribner Decimal C rule. Mr. Bruce states that in later work he has been using graphic methods of interpolation of even less refinement than those used by the writer.

The following methods of constructing volume tables were used in this study:

(1) The conventional method in which the average volume, total merchantable length, and d. b. h. are computed for all trees falling in a given d. b. h. and log class. These data are usually compiled in the form of a series of tables, one for each d. b. h. and log class. The average diameters breast high and volumes are rounded off for the several log classes by a series of curves and the average volume for each integral d. b. h. class is read from the curves. The average merchantable lengths and volumes are then computed for all d. b. h. classes and the average volume for each integral log class is read from the curve. It is often necessary to further round off these values by another series of harmonized curves from which the final volume table is read.

(2) This method uses one average frustum form factor for all d. b. h. and log classes. A tabulation is made showing for each individual tree the d. b. h., merchantable length, volume in board feet as actually scaled, the volume of the corresponding frustum which is read from the table of frustum volumes, and the frustum form factor. To obtain the values

used in the final volume table, the frustum form factors are averaged and the values in the table of frustum volumes are multiplied by the average frustum form factor.

(3) The average frustum form factor is computed for each d. b. h. class regardless of the log class. The average form factors for each diameter class are rounded off by a curve. The values used in the final volume table are obtained by multiplying the values for each d. b. h. class in the table of frustum volumes by the frustum form factor which was read from the curve for that diameter class.

(4) The average frustum form factor is computed for each d. b. h. and log class. A series of tables, showing for each d. b. h. and log class the actual d. b. h., merchantable length, and volume of each tree, is made as in method 1; but, instead of carrying forward the average volume, the frustum form factor is computed for each d. b. h. and log class. The frustum form factors are then averaged by a series of harmonized curves, just as the volumes are averaged in the conventional method. The last step involves the transformation of the form factors to board-foot volumes by applying each form factor to the volume of the frustum of a cone of the same d. b. h. and log class.

Volume tables constructed by the above-mentioned methods were compared as to accuracy by checking each with the gross log scale of three different sets of trees.

In methods 3 and 4, 200 trees were selected at random, representing each diameter class by about the same number of trees. In method 2, the arithmetical average of the frustum form factors for each d. b. h. class and the same after being averaged by a curve was tabulated for each diameter class. Volume Table A was made by multiplying the frustum volumes for a given d. b. h. class by the corresponding form factors. The same 200 trees were then worked up by method 4. The frustum form factors were averaged by d. b. h. and log classes, by a series of harmonized curves, which, when applied to the table of frustum volumes, resulted in Volume Table B. Volume Table C was constructed from the same trees by the conventional method.

Another set of 200 trees was selected at random, in which each diameter class was represented in about the same proportion as in the 1913 Coconino-Tusayan table. Volume Tables D, E, and F were constructed from these trees by methods 3, 4, and 1, respectively.

Method 2 was tested by two sets of 25 trees each. The trees were selected so that each of the 25 diameter classes was represented by one tree. Volume Tables G and H were obtained by applying the average frustum form factor for each set of data to the table of frustum volumes.

Volume Tables A, B, C, D, E, F, G, and H, together with the 1906 Coconino and the 1913 Coconino-Tusayan tables, were checked by comparing the total full or gross log scale of 50 trees with the total volume of the same trees as computed from the respective volume tables. The difference between these two quantities multiplied by 100 and divided by the total full log scale gives the per cent of error. Because of the variable results of this check two other checks of 111 and 500 trees were made. In all of these checks none of the trees used in constructing the tables were used in making the checks. Greater weight should be given to the check based on 500 trees, since volume tables are used for determining the volume of a large number of trees or of tracts of timber of considerable area. Volume tables are unreliable for a few trees, as was shown by the different checks.

RESULTS AND CONCLUSIONS

Tables 1, 2, and 3 show method 4 to be the most accurate. Tables 2 and 3 uniformly show that method 1 is the most inaccurate of the methods used in constructing the volume tables considered in this check, while method 3 ranks next to method 4 in accuracy.

Method 1 was found to give the most inaccurate table when based on as few as 200 trees. Too much is left to the discretion of the person drawing the curves, on account of the few and widely distributed points at the extreme ends of the curves. A graphical comparison of the forms of the volume and frustum form factor curves was made by plotting two series of curves, each series covering all log classes, the one with volume on d. b. h. and the other with the frustum form factors on d. b. h. When a large scale is used, as is the case in actual practice, the contrast is more marked. The form factor curves are flatter and continue to flatten perceptibly as the larger d. b. h. and log classes are reached, while the reverse is true in the case of the volume curves. An improper direction or location of the volume curve will make a considerable difference in the volume of the larger diameter and log classes, while at most a difference of only a few hundredths would be made in the frustum form factor curve for the larger d. b. h. and log classes.

The summary of the three checks, Table 1, indicates that, with the exception of method 1, when based upon a small number of trees, all the methods tried are sufficiently accurate for practically all purposes for which a volume table is required. When we consider that a scaler is doing satisfactory work if he comes within two or three per cent of the check scale, and that reconnaissance estimates are regarded as satisfactory if they are within 15 to 20 per cent of the actual scale of the timber

on the area involved, it is not consistent to demand tables which are more accurate than two per cent.

The average frustum form factors used in constructing Volume Tables G and H were checked, as suggested by Bruce, by the result obtained from calculating the probable error of the average values of each group of measurements used. The simplest formula to apply is the approximation formula as used in the theory of least squares:

$$E = \frac{.8453\ Sv}{n\sqrt{n-1}}$$

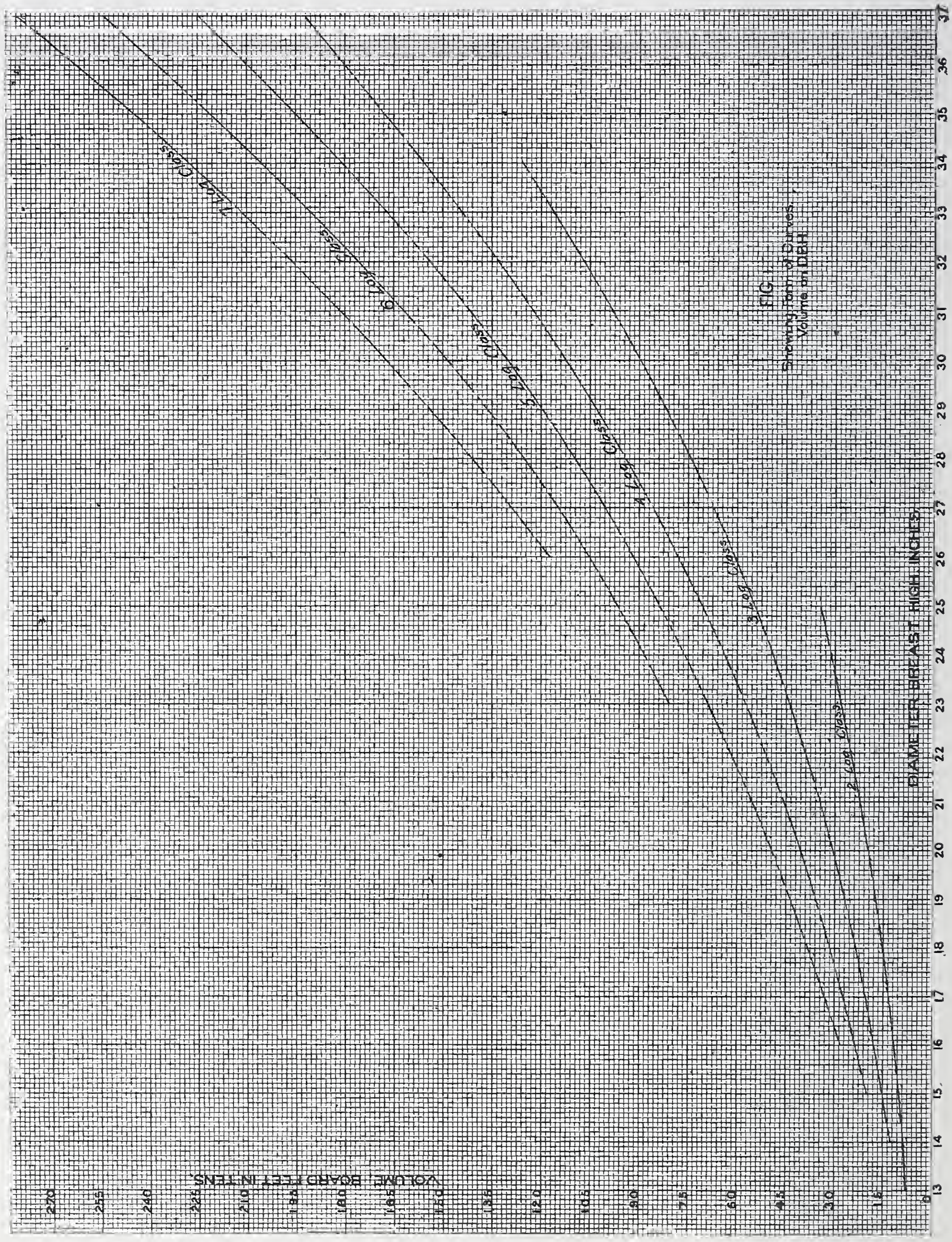
in which E is the probable error, .8453 a constant, Sv the sum of the deviations of the individual values from the mean, and n the number of values. Applying the formula to the form factors used in obtaining the average with which to construct Volume Table G, Sv is 4.65, n 25, and E is found to be .032; with Volume Table H, Sv is 6.79, n 25, and E is .0406, showing that there is an even chance that the average form factors 1.07 and 1.04 used in constructing Volume Tables G and H are within three and four per cent respectively of the correct form factors. This indicates that Volume Tables G and H would in all probability give results within three and four per cent of the correct volumes, although all of the other checks showed more accurate results.

In an attempt to get an indication of the mathematical accuracy, as shown by the maximum and minimum individual variations of the four methods of constructing volume tables, the values given in all tables were plotted for the 3, 5, and 7 log classes and compared with those of the 1913 Coconino-Tusayan table, which was based on 6,094 trees.

Figure 1 shows the curves for the 3-log class of the ten tables studied. The great divergence of Volume Tables G and H is especially conspicuous. For the smaller diameter classes the values are too high, while for the larger diameter classes they are too low. In the usual checks representing all diameter classes, such as those used to obtain the results shown in Table 1, the individual errors are averaged, so that the final per cent of error is generally quite small. If, however, the tables constructed by method 2 were applied to a mature stand containing a great many large trees or to an immature stand of small timber the errors would be enormous. This indicates that the table showing the minimum individual variation, as well as the minimum aggregate error, is the most desirable. The usefulness of this method is restricted to local volume tables; local by age as well as by site.

The curves of the tables constructed by the same frustum method are quite regular and closely approach a parallelism, while those of the conventional method are irregular and often cross each other.

Figure 1 also shows that method 4 is the most accurate when the same number of trees are used in each case. The curves are not only regular, but they follow closely the same course as those of the 1913 Coconino-



Tusayan table which was used as the standard of comparison. Because of the above-mentioned reasons greater emphasis should be placed on this test than on the checks shown in Table 1, although both should be considered.

In working with the volume data which were collected on the Coconino National Forest, it was noticed that there was a marked difference in the merchantable lengths and total heights of the trees on two different timber-sale areas not more than 30 or 40 miles apart. The one area has a sandy, adobe, clay soil, with many malpais rocks of volcanic origin scattered through it. The soil on the other sale area contains a greater proportion of coarse material in the form of black volcanic cinders. Besides having a soil of coarser texture which is deficient in organic matter, less precipitation is received on this area than on the malpais. The above conditions render the site more unfavorable, causing the timber to be much shorter and more limby than on the malpais soil.

Table 4 shows the result of a comparison of all available trees on the two sites falling in the same d. b. h. and log classes. The 86 trees show that for the same d. b. h. and log class the timber growing on the malpais soil had a volume 11.1 per cent greater than that on the cinder soil. This result was rather to be expected, since within the same diameter class the shorter the timber the greater the taper, and with the greater taper a smaller volume is found within the same d. b. h. and log class. The average top diameter of the trees grown on the cinder soil was 0.7 of an inch less than that of those grown on the malpais soil. This shows that the trees on the cinder soil had a greater taper. It is also very probable that there is a difference in the form of the trees, the timber on the malpais soil being decidedly full-boled, while that on the cinder soil is not. However, further investigation is needed to substantiate this theory.

The above-noted difference in the two timber-sale areas brings up the idea, which has been advocated by American foresters for the last ten or fifteen years, that local rather than general volume tables should be used in this country. It is true that the Germans use general volume tables, but their forests are regular, have been under intensive management for a long time, and the average contents of the individual trees are fairly uniform. The American forests, particularly those of the Southwest, are very irregular and are attended by very variable conditions which influence the growth of trees both as to form and volume. A table constructed from the data collected in the same immediate locality in which it is expected to be used is considered more accurate for scientific work than a general table applicable to the entire region. In all cases, however, a careful analysis should be made of the conditions under which local volume tables are required.

The question, which of the frustum methods to use, must be settled in each individual case, depending largely upon the number of measurements which will be available for the table. Because of the irregularity

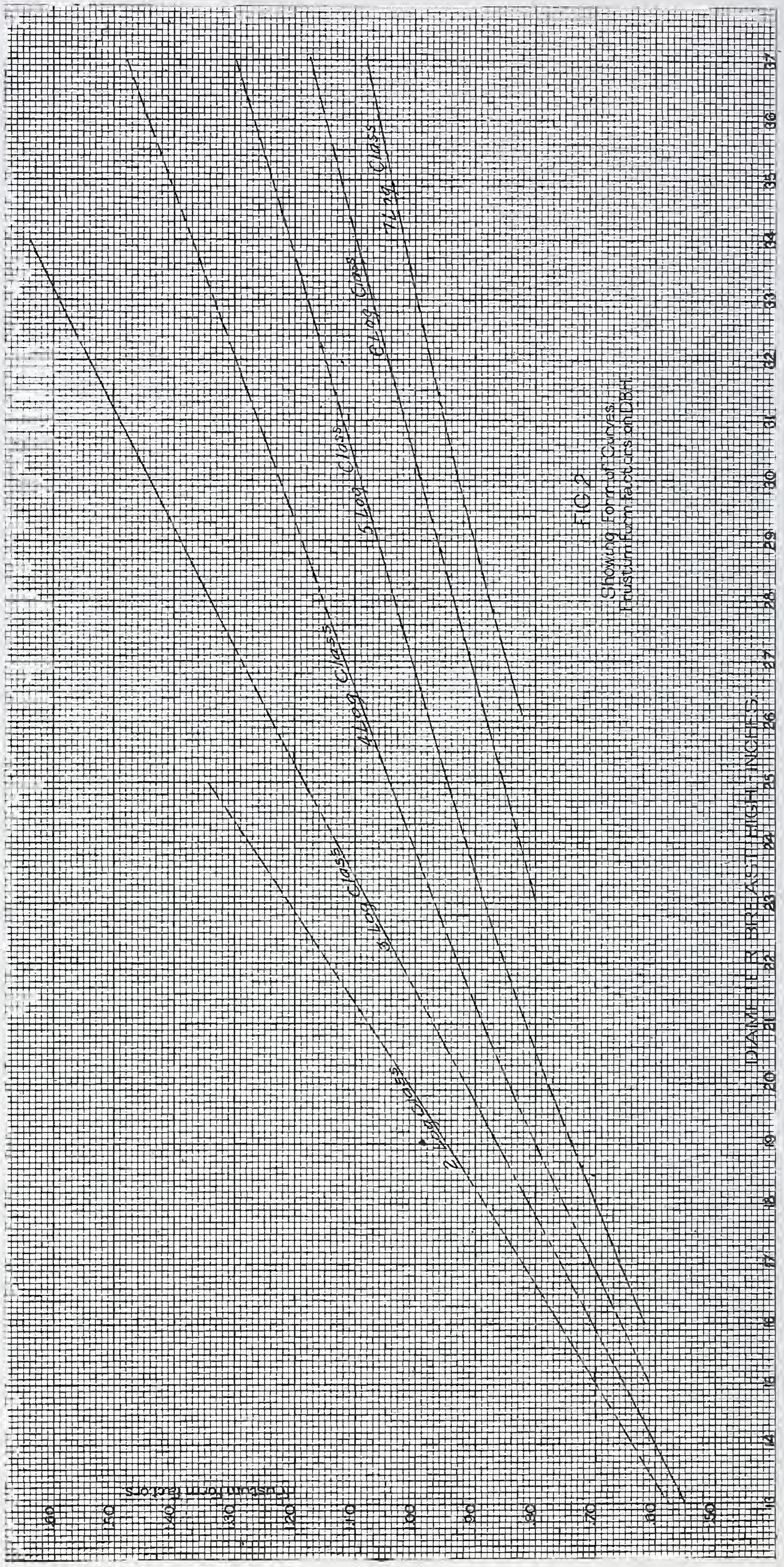


FIG. 2
Showing Form of Curves.
Frustum Form Factors on DBH.
DIAMETER BREAST HIGH: INCHES.
Frustum Form Factors
2 Log Class
3 Log Class
4 Log Class
5 Log Class
6 Log Class
7 Log Class
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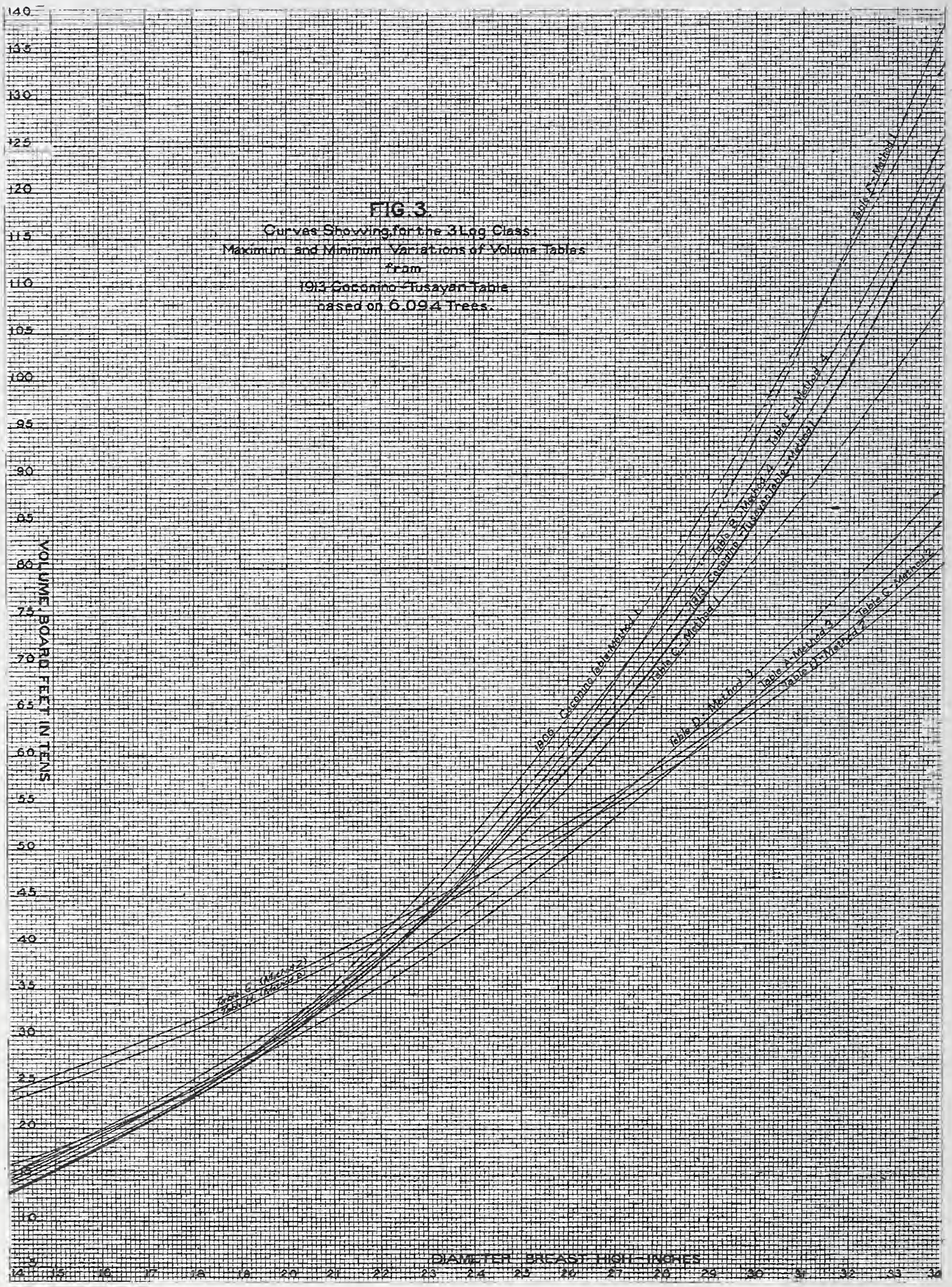
of the frustum form factors, less than 50 trees should not be considered for a western yellow-pine volume table. When 50 to 100 trees are available, method 2, using one average form factor for the entire table, should be employed. If 150 to 250 trees are available, method 3, using an average form factor for each d. b. h. class, is preferable. With 300 to 500 available measurements, method 4, in which the frustum form factors are averaged by a series of harmonized curves, just as the volumes are averaged in the conventional method, should be used. Only in exceptional cases, in which the practical utility of the proposed table does not warrant the collection of adequate data for the use of method 4, should method 2 or 3 be used. A well-constructed volume table classified by diameter and height gives the volumes of average trees of each dimension. These average volumes are much more reliable than the volumes of a few trees which may have decided eccentricities of form and not conform at all to the true average. Extreme care should be exercised in collecting the field data, not only to see that in methods 2 and 3 the diameter classes are uniformly represented and in method 4 as many diameter and height classes are represented as possible, but also to select normal trees having representative volumes.

A study of Table 1 indicates that a fairly satisfactory volume table may be constructed by the frustum form factor method at from 5 to 20 per cent of the cost by the conventional method. This advantage alone should be argument enough for making a detailed and thorough investigation of the method both as to its mathematical accuracy and adaptability to the commercially important species of all the forest regions of the United States.

The work done so far with western yellow pine shows an increase in the form factors, with an increase in diameter and a decrease with an increase in merchantable length. It seems reasonable to assume that the frustum form factors indicate some definite law of form or growth for any given species. The fact that the frustum form factors for western yellow pine exhibit a much wider range and increase with an increase in diameter, while with western larch, Douglas fir, Engelmann spruce, western red cedar, and western white pine the form factors decrease with an increase in diameter, adds materially to the above theory. The decrease is undoubtedly due to the rise of the root-swelling, making the trees more buttressed and the thicker bark at the point of measurement. An opposite tendency in the western yellow pine results from the low root-swelling and the tendency of the tree to concentrate its taper at the extreme upper portion of the bole, particularly in the larger diameter classes. The greater irregularity of the frustum form factors is largely ascribed

to the thicker bark and more irregular form and volume of the western yellow pine. Contrary to the opinion of many European authorities, that



stem form factors, and the assumption by Bruce, that a table of frustum form factors, may be based on diameters alone, Table 5 shows that, at least for western yellow pine, there is sufficient variation in the frustum

form factors in the different log classes to warrant basing a table of frustum form factors not on diameter alone, but on diameter height. Figure 1 further exemplifies this statement.

Incidental to other field-work, further studies are contemplated during the coming field season looking toward determining the form of western yellow pine and the mathematical accuracy of the frustum form factor method as compared with the conventional method of constructing volume tables.

It is freely admitted that the data herein presented is not entirely conclusive. As mentioned above, further investigations not only with western yellow pine, but with Douglas fir and Engelmann spruce, are desirable before final conclusions may be deduced as to the general adaptability of the frustum form factor method to the species of the Southwest. The results of the study made in District 3, although not quite as sweeping as those of Bruce's study in District 1, indicate that the frustum form factor method of constructing volume tables is applicable to western yellow pine in the Southwest. This study warrants the following conclusions:

1. There is a need for more local and fewer general volume tables. This can be more easily accomplished by the frustum form factor than by the conventional method.

2. The use of the frustum form factor method eliminates the variation in the merchantable length of trees in the same d. b. h. and height class because the full-boled tree has a greater volume, and consequently a larger frustum form factor, than a more rapidly tapering tree having the same diameter and total height. This is due to the fact that either more or longer logs can be cut from the stem of a full-boled tree and their top diameters are larger.

3. Because the frustum form factor curves are flatter and continue to flatten as the larger d. b. h. and log classes are reached, the location and direction of the curves can be more easily determined, leaving less possibility for error than with the volume curves of the conventional method.

4. The method which involves the use of an average frustum form factor for each diameter and height class is mathematically the most accurate, giving a minimum variation.

5. The number of measurements needed for a satisfactory and fairly accurate table by the frustum form factor method is considerably less than when the conventional method is used.

6. Compared with the conventional method, the cost of constructing a volume table of a like degree of accuracy by the frustum method is materially reduced.

TABLE 1.—*Summary of Checks.*

Name of table.	Method of construction.	Basis number trees.	Approximate cost of table.	Per cent of error.		
				50-tree check.	111-tree check.	500-tree check.
Coconino-Tusayan, 1913......	1	6,094	$1,500.00	+0.6	+1.4	+0.03
Coconino, 1906..	1	1,863	[1] 200.00	—1.1	+1.8	—0.03
C...........	1	200	35.00	+0.7	—0.1	—1.6
F...........	1	200	35.00	+3.0	+4.2	+2.6
G...........	2	25	8.00	—1.5	+1.8	—0.2
H...........	2	25	8.00	—1.5	—1.0	—2.8
A...........	3	200	30.00	—1.9	—1.4	—2.8
D...........	3	200	30.00	+1.4	+1.8	+0.4
B...........	4	200	35.00	—0.4	—1.4	—2.6
E...........	4	200	35.00	+0.6	+2.4	+0.7

[1] The actual cost of the 1906 Coconino table was considerably reduced by employing rangers receiving $60 per month and doing much of the work in connection with routine timber-sale supervision and outside of official hours. Were the same table to be constructed now it would probably cost $500.

TABLE 2.—*Check of Volume Tables A, B, and C with Same 200 Trees Used in Construction.*

Name of table.	Method of construction.	Scale by volume table. Feet, B. M.	Per cent of error.
C................................	1	186,950	+1.7
A................................	3	184,600	+0.4
B................................	4	184,110	+0.1

Actual log scale, 183,900.

TABLE 3.—*Check of Volume Tables D, E, and F with Same 200 Trees Used in Construction.*

Name of table.	Method of construction.	Scale by volume table. Feet, B. M.	Per cent of error.
F................................	1	149,010	+2.5
D................................	3	147,920	+1.8
E................................	4	146,330	+0.7

Actual log scale, 145,310.

TABLE 4—*Comparison of Timber on Malpais and Cinder Soil.*

D.B.H.	Soil.	Log class. 3		4		5		6		Totals.	
		Full scale.	Basis.	Full scale.	Basis.	Full scale.	Basis.	Full scale.	Basis.	Full scale.	Basis. No. trees.
20	Malpais......	174	5	108	3	......	..	......	..	282	8
	Cinder.......	158	5	124	3	......	..	......	..	282	8
22	Malpais......	226	6	633	12	......	..	......	..	859	18
	Cinder.......	223	6	555	12	......	..	......	..	778	18
24	Malpais......	128	3	339	6	......	..	......	..	467	9
	Cinder.......	126	3	316	6	......	..	......	..	442	9
26	Malpais......	......	..	673	8	......	..	......	..	673	8
	Cinder.......	......	..	525	8	......	..	......	..	525	8
28	Malpais......	......	..	212	2	526	5	......	..	738	7
	Cinder.......	......	..	131	2	436	5	......	..	567	7
30	Malpais......	......	..	603	6	1,059	8	......	..	1,662	14
	Cinder.......	......	..	526	6	944	8	......	..	1,470	14
32	Malpais......	......	..	117	1	1,314	9	175	1	1,606	11
	Cinder.......	......	..	94	1	1,232	9	182	1	1,508	11
34	Malpais......	......	..	......	..	743	4	404	2	1,147	6
	Cinder.......	......	..	......	..	716	4	359	2	1,075	6
36	Malpais......	......	..	......	..	446	2	250	1	696	3
	Cinder.......	......	..	......	..	399	2	195	1	594	3
38	Malpais......	......	..	......	..	170	1	211	1	381	2
	Cinder.......	......	..	......	..	176	1	245	1	421	2
Totals..	Malpais......	5,280	14	26,850	38	42,580	29	10,400	5	85,110	86
	Cinder.......	5,070	14	22,710	38	39,030	29	9,810	5	76,620	86

Timber on malpais soil has 11.1 per cent greater volume for same d. b. h. and log class.

TABLE 5.—*Frustum Form Factors Curved by D. B. H. and Log Classes.*

Method 4.—Preliminary to Volume Table E.

D. B. H.	Merchantable length No. 16-foot logs.						Basis No. trees.
	2	3	4	5	6	7	
	Frustum form factors.						
13	.58	.55	....	....	....	....	1
14	.64	.60	....	....	....	....	5
15	.70	.65	.61	....	....	....	9
16	.76	.70	.66	.62	....	....	10
17	.82	.75	.70	.66	....	....	11
18	.89	.81	.75	.70	....	....	11
19	.95	.86	.80	.74	....	....	11
20	1.02	.92	.84	.78	....	....	8
21	1.08	.97	.89	.82	....	....	11
22	1.15	1.03	.93	.85	....	....	12
23	1.22	1.08	.97	.88	.80	....	12
24	1.28	1.13	1.01	.91	.82	....	11
25	1.34	1.19	1.05	.94	.85	....	11
26	....	1.24	1.08	.96	.87	.82	13
27	....	1.29	1.12	.99	.90	.85	12
28	....	1.34	1.15	1.02	.93	.88	9
29	....	1.39	1.17	1.05	.96	.90	8
30	....	1.44	1.22	1.08	.99	.93	7
31	....	1.49	1.26	1.12	1.01	.95	5
32	....	1.54	1.29	1.14	1.04	.97	6
33	....	1.59	1.33	1.17	1.07	.99	5
34	....	1.64	1.37	1.20	1.10	1.02	4
35	....	....	1.41	1.23	1.12	1.04	3
36	....	....	1.44	1.27	1.15	1.06	3
37	....	....	1.48	1.30	1.17	1.08	2
							200

FURTHER NOTES ON FRUSTUM FORM FACTOR VOLUME TABLES

BY DONALD BRUCE

Contributed

APPLICABILITY OF METHOD TO DOUGLAS FIR, WESTERN LARCH, AND ENGELMANN SPRUCE

"The Use of Frustum Form Factors in Constructing Volume Tables" was discussed in the October, 1913, number of the Proceedings, wherein data were presented showing the applicability of this method to western white pine. Since then considerable additional work[1] has been done on other coniferous species, which, in general, confirms the conclusions already reached. The species investigated were western larch, Engelmann spruce, and Douglas fir, while the white-pine table presented in the above-mentioned article was revised and strengthened by the use of additional data in the larger diameter classes. It is interesting to note the similarity in the trend of the values obtained for the several species. The following diagram (figure 1) shows this in graphic form. In the case of each species there is a noticeable tendency toward a double reverse curve. The portion of the curves where the change in values is rapid undoubtedly corresponds to the diameter classes where the root-swelling first reaches high enough to affect the d. b. h. measurement. It is worth noting, however, that partial work on yellow pine (which was unsatisfactory on account of meager data and the fact that the measurements used had not been uniformly taken) indicates a very different curve for that species, the values rising with the the d. b. h. instead of falling. This probably depends on the tendency of the yellow pine toward an unusually full bole in the larger sizes and on its relatively low root-swelling.

From all the values above given volume tables were made which have been quite thoroughly checked. The results which are given in Table 1 speak for themselves. The checks were not made in any systematic way, being dependent on limited existing data, but seem to indicate the essential accuracy of tables thus prepared. In three cases it will be noted that more than one table was prepared and tested to indicate the advan-

[1]Acknowledgment is made to Messrs. J. B. Somers and S. S. Malven for valuable assistance rendered in this work.

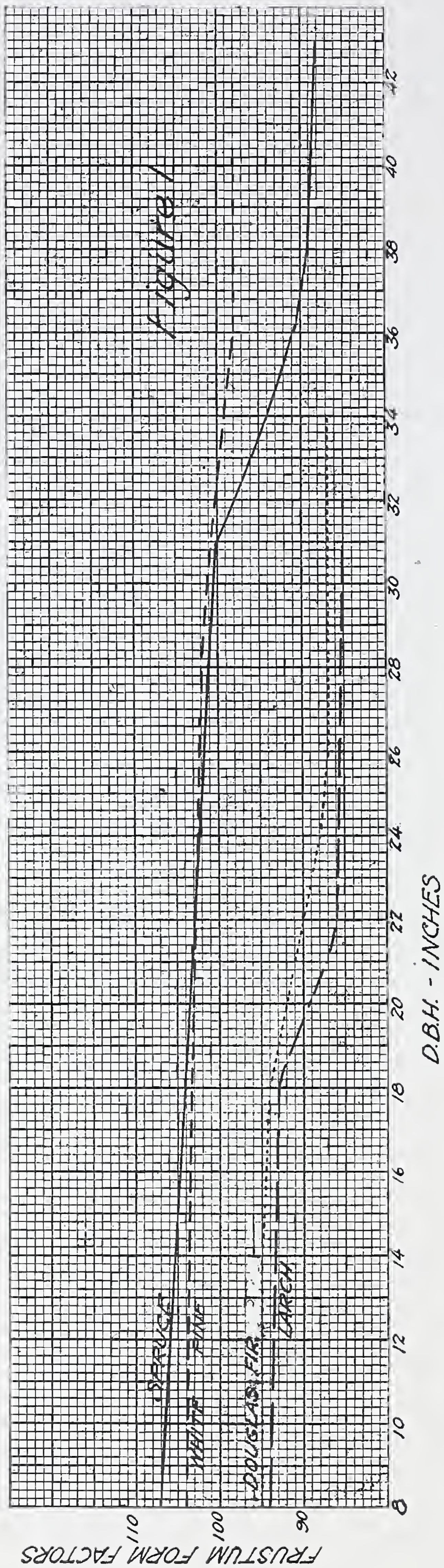


Figure 1
SPRUCE
WHITE PINE
DOUGLAS FIR
LARCH
D.B.H. - INCHES
FRUSTUM FORM FACTORS
110
100
90

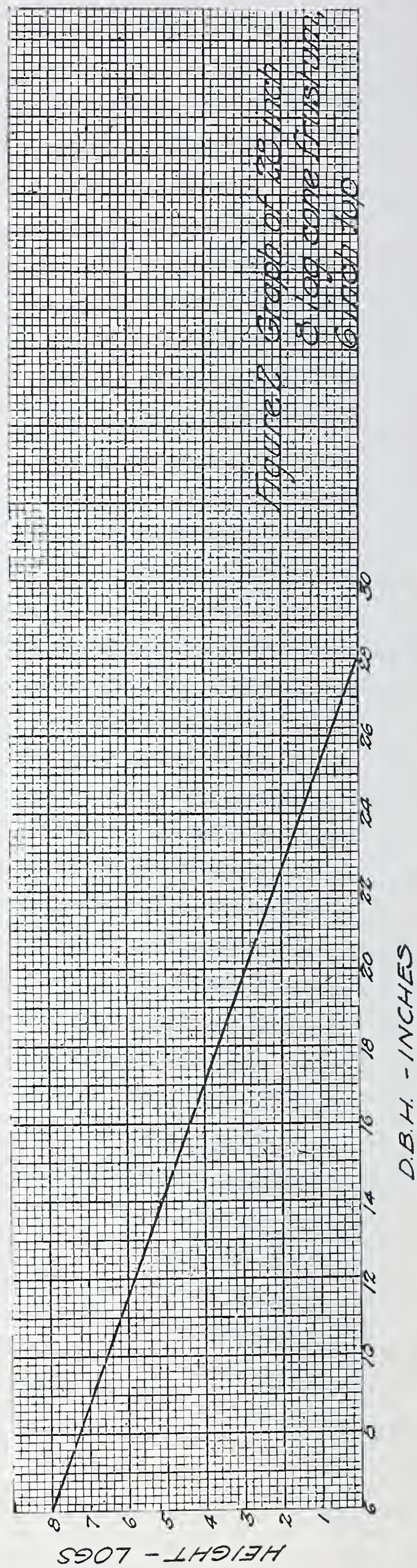


Figure 2 Graph of 28 inch
8 log cone frustum,
6 inch top
D.B.H. - INCHES
HEIGHT - LOGS

tage gained by additional measurements. The final tables prepared were of necessity left unchecked, since all of the available tree measurements had been used in their preparation.

It is also of interest to note the small variations apparently introduced by location. In white pine, for example, the error resulting from using a table prepared from trees coming from the Cœur d'Alene and St. Joe Forests (the heart of the white-pine region) for estimating Blackfeet Forest timber growing on the extreme eastern limits of the species range is surprisingly small and in marked contrast to the 8 per cent error discovered in using the same table on Kaniksu timber, as described in the article above referred to. It should be added that the Kaniksu timber was almost exclusively growing on deep-soiled flats, while the Blackfeet, Cœur d'Alene, and St. Joe trees alike grew on steep slopes. It is forcibly suggested that particular sites demand local volume tables much more than do similar sites in geographically remote regions, at least for the species under consideration.

SOME SHORT-CUT METHODS

It was found possible to materially shorten the work of constructing these tables in three ways, as follows:

(A) In the preparation of the base table of volumes of frustums of cones scaled in 16-foot logs one of the laborious steps is the determination of the top diameter of each of these logs. This can be done graphically instead of by calculation in a fraction of the time. The graphic solution is too obvious to need detailed explanation beyond calling attention to the fact that in making the diagram of each cone frustum the vertical or height scale in feet can be made equal to the horizontal or diameter scale in inches, thus contracting the diagram into the limits of convenient cross-section paper. Figure 2 shows the graph of an 8-log, 28-inch d. b. h. frustum. From this the top of the seventh log is seen to be 8.7 inches, etc.

(B) In working out the average frustum form factor for each diameter class it is not necessary to calculate the factor for each individual tree as was indicated in the previous article. The sum of the actual volumes of all the trees in the diameter class can be obtained and divided by the sum of all the volumes of the corresponding cone frustums, thus giving the average frustum form factor for the class directly.

(C) The largest saving can be made in connection with obtaining the volume of the frustum of the cone corresponding to each given tree for which data is available. Unless the number of tree measurements is very large, it is quite necessary to interpolate to the nearest foot in height and

TABLE 1.

Table.			Check.		Scale—feet B. M.			Error, per cent.
Species.	Source—forest.	Basis—trees.	Source.	Number trees.	Actual.	Volume table.	Error.	
Western white pine....	Cœur d'Alene and St. Joe.	160	Blackfeet ...	81	27,260	26,690	570	—2.1
Western white pine....	Misc.	289	Misc.	380	291,753	289,324	2,429	— .8
		...	Blackfeet ...	81	27,260	26,920	340	—1.2
Western larch..........	Misc.	185	Blackfeet ...	30	13,430	13,110	320	—2.4
		...	Lolo	63	43,200	43,750	550	+1.3
Engelmann spruce......	Blackfeet	45	Lolo	25	18,330	18,830	500	+2.7
Engelmann spruce......	Blackfeet and Lolo.......	187	Lolo	50	51,280	52,470	1,190	+2.3
Douglas fir............	Blackfeet	117	Lolo	61	9,645	9,910	265	+2.8
Douglas fir............	Blackfeet and Lolo.......	311	Lolo	73	65,930	64,370	1,560	—2.4

the nearest tenth of an inch in diameter. The tedious work of this double interpolation can be much shortened by graphic methods. A set of curves may be prepared for the base table of frustum of cone volumes. A separate curve should be drawn for each height class, the horizontal distances expressing d. b. h.'s and the vertical distances volume in feet b. m. The result is in all ways parallel to the final curves drawn in constructing volume tables by the conventional method. It is also helpful to draw curves for quarter-log height classes. (If these are spaced evenly between the full log curves, no serious error is introduced.) To find the volume of any given cone frustum, it is then only necessary to select by inspection a point on the proper d. b. h. line and properly intermediate between the next higher and lower height curves, its volumes being then read directly from the vertical scale. After a little practice this can be done with great rapidity and with entirely satisfactory accuracy.

It is believed that the three modifications together cut the office work of volume-table construction by this method at least in half, reducing the expense of preparation of frustum form factor tables very materially below the figures given in the previous article.

A "UNIVERSAL VOLUME TABLE"

The frustum form factor method offers an approach to the much-sought-after "universal volume table." A true universal table is probably a Utopian conception, but the base table of frustum of cone values has been used with success for several different species by the application of proper correction factors. These factors are, of course, derived directly from the frustum form factor values. Table 2 illustrates the idea suggested. It should be noted, however, that the values given for lowland and alpine fir and for yellow pine are tentative and not well established.

TABLE 2.—*"Universal" Volume Table. Base Volume Table. Scribner Decimal C Rule.*

D. B. H.	Height in logs.									
	1¼	2	3	4	5	6	7	8	9	10
8.....	2	5	7	10	...	...	...	....	....	....
10.....	3	5	9	12	...	...	...	....	....	....
12.....	3	6	10	15	19	23	...	....	....	....
14.....	3	7	13	18	24	30	35	41	....	....
16.....	3	8	15	22	29	37	45	52	60	67
18.....	4	10	18	28	37	45	55	64	73	83
20.....	4	12	23	33	44	56	66	79	90	101
22.....	5	13	26	39	53	67	81	95	109	122
24.....	5	16	31	47	63	80	95	112	128	145
26.....	6	18	36	55	73	93	113	130	150	168
28.....	6	20	42	63	85	107	130	153	175	197
30.....	...	23	47	71	99	123	150	175	200	227
32.....	...	26	54	83	112	140	169	197	227	255
34.....	...	30	61	94	124	157	189	223	256	288
36.....	...	32	68	102	137	176	211	245	282	319
38.....	...	35	75	112	153	192	230	269	312	351
40.....	...	39	81	125	168	209	256	300	343	390
42.....	...	42	89	135	184	229	283	331	376	427
44.....	...	48	97	147	200	257	308	361	416	469
46.....	...	52	104	160	219	278	334	395	456	510
48.....	...	57	110	179	240	302	364	434	491	559
50.....	...	60	120	190	259	327	400	462	534	605
52.....	...	63	133	206	277	354	425	500	578	648
54.....	...	68	142	223	299	378	460	537	619	699
56.....	...	73	153	239	319	407	492	582	661	749
58.....	...	75	165	251	346	435	525	616	708	804
60.....	...	80	176	269	367	464	561	661	755	856
62.....	...	82	188	283	391	490	596	702	809	907
64.....	...	89	200	302	415	524	636	748	856	966
66.....	...	94	211	320	441	554	675	790	910	1.025
68.....	...	105	223	343	467	592	714	840	964	1.092
70.....	...	109	236	360	493	625	753	885	1,020	1,154
72.....	...	114	247	380	518	658	796	938	1,075	1,214
74.....	...	122	259	404	546	695	839	990	1,136	1.283
76.....	...	129	272	425	572	732	883	1,041	1,197	1,352
78.....	...	136	286	446	603	770	935	1.095	1,257	1,424
80.....	...	141	301	469	633	809	981	1,149	1,322	1,494

TABLE 2—Continued. *Species Factors.*

D. B. H.	Species.						
	Western white pine.	Western larch.	Lowland fir.	Engelmann spruce.	Alpine fir.	Douglas fir.	Western yellow pine.
8......	1.04	.94	1.03	1.07	1.08	.95	.99
10......	1.04	.94	1.03	1.06	1.08	.95	.99
12......	1.04	.94	1.03	1.06	1.08	.95	.99
14......	1.04	.94	1.03	1.05	1.08	.94	1.00
16......	1.04	.93	1.03	1.05	1.08	.94	1.00
18......	1.04	.93	1.03	1.04	1.08	.93	1.00
20......	1.03	.89	1.03	1.03	1.08	.92	1.02
22......	1.03	.86	1.03	1.03	1.08	.90	1.04
24......	1.03	.86	1.03	1.02	1.08	.88	1.06
26......	1.02	.85	1.03	1.02	....	.87	1.08
28......	1.02	.84	1.03	1.01	....	.87	1.08
30......	1.01	.84	....	1.00	....	.87	1.08
32......	1.01	.82	....	.99	....	.87	....
34......	1.00	.79	....	.94	....	.87	....
36......	.99	.78	....	.91	....	.87	....
38......	.98	.76	....	.89	....	....	....
40......	.98	.75	....	.89	....	....	....

In use in ordinary estimating, the volume of each species on the tally sheet is computed by the above base table, and when the several values are listed the center of gravity by volume of the diameters represented is estimated and the corresponding value taken from the appended table of species factors. The resulting total must then be combined with the deduction usually made for cull, thus introducing practically no extra work. The accuracy of the table used in this manner has been tested by figuring up eight "forty" estimate sheets, first by this method and then by the use of separate species volume tables. The total errors by "forties" averaged 4/10 of 1 per cent, with a maximum of 1 and 2/100 per cent. The aggregate error for the eight "forties" was 16/100 of 1 per cent. The greatest error for any species on any "forty" was 4 per cent, while the average species error for the individual "forties" was 67/100 of 1 per cent. The aggregate species error for the group of "forties" averaged 3/10 of 1 per cent, with a maximum of 7/10 of 1 per cent.

In routine estimating species tables will probably always be used; but wherever there is a decided advantage in reducing the tables carried to one, these checks seems to indicate that a table such as the above introduces but relatively insignificant errors.

REVIEWS

The Sequoia and the Former Climate of California

In a recent review of "The Climatic Factor," Professor Carter accepts the main idea of that volume, but questions one important conclusion. He thinks that stump analyses of the *Sequoia washingtoniana* of the Sierra Nevadas prove beyond reasonable doubt that during the last three thousand years the climate of that region has been subject to distinct pulsations larger than those now observable from decade to decade. He is not convinced, however, that the average climate for, let us say, a thousand years before Christ was different from the average for the past thousand years. He especially questions the use of the Caspian Sea as a measuring rod by which to determine how much, if any, the corrected curve of growth of the sequoia should be tilted in order to give a true representation of the climate of the past.

It seems to me that there is abundant evidence that similar climatic provinces in Asia and America pass through similar climatic vicissitudes. Nevertheless, as I have stated in "The Climatic Factor," I realize that the use of the Caspian Sea and other Asiatic evidence as a scale applicable to a region ten thousand miles away is open to serious question. The only justification is that in America there are no accurately dated ruins or other works of man which serve as a scale to determine the times when important climatic vicissitudes occurred. Fortunately, however, the work of Dr. H. S. Gale, of the U. S. Geological Survey, has recently furnished an approximate scale which may safely be substituted for that of the Caspian Sea.

Owens Lake is a small body of salt water lying at the eastern base of the Sierra Nevadas and only fifty miles from the two regions where the sequoias were measured. Its area in 1913 was 97.2 square miles, its depth about 30 feet, and its altitude 3,577 feet. Practically all of its water supply comes from the Owens River, which flows southward in a long, straight trough not unlike that of the Jordan River on its way to the Dead Sea. Within the last few years the Owens River has been diverted from its natural course, and now flows to Los Angeles through an aqueduct over two hundred miles long. In connection with this diversion, the volume and salinity of both the river and the lake have been

measured with great accuracy. In Bulletin 580–L of the United States Geological Survey, Dr. Gale describes these measurements, and reaches the following conclusion as to the "geologic age of Owens Lake" (pp. 263–264):

"The idea of calculating the age of a land-locked lake from an estimated annual rate of accumulation of its dissolved saline constituents is not new. The results thus obtained cannot be considered wholly satisfactory, for in spite of certain factors that may be quantitatively measured there must always remain other essential factors which cannot be exactly determined and which must rest largely on assumption. The total volume of Owens Lake, its composition, and the quantity and composition of its inflowing waters are now known with a considerable degree of exactness. . . . The total chlorine content of the lake waters is approximately 40,000,000 short tons. If the annual contribution of chlorine from the flow of Owens River has been 9,500 tons [the rate indicated by recent analyses extending through two full years at intervals of ten days], it has required 4,200 years for the accumulation of this total amount of chlorine.

"By similar reasoning, the total sodium content of the lake waters is 60,000,000 tons. If the annual contribution of sodium from the inflowing waters is 17,000 tons, this represents some 3,500 years of accumulation.

"If such computations were worthy of even greater degree of refinement allowance might be made for the total quantity of the elements that may have been contained in the lake waters when the lake last ceased to overflow. [This overflow continued for a long period, during which the water stood at an altitude of 190 feet or more above the present level.] In a rough way, however, it may be assumed that the figures given represent the time occupied by the last stage of the lake history—namely, that since water last ceased to overflow—during which the waters have by accumulation and evaporation concentrated the more stable dissolved constituents at a fairly definite annual rate."

When the lake overflowed the evaporating surface was two and one-half times as large as now, and the volume of the river must have been correspondingly large. This might seem to indicate that a proportionally large amount of salt was also then brought in, but Gale thinks that "there probably was then a diminution in the relative proportion of dissolved salts." Even so, this factor, as well as the amount of salines in the lake waters when they ceased to overflow, would tend to diminish the period required to accumulate the present amount of salt. Hence Gale's final conclusion is that "the length of time it has taken to accomplish this accumulation is in very general terms about 4,000 years, or possibly considerably less."

During these 4,000 years or less the lake has not fallen at a uniform rate. The fall was first checked or changed to a rise in such a way as to

form "an uppermost distinct beach and barrier bar at an elevation of about 3,700 feet" (p. 256)—that is, 60 feet below the old outlet. A similar checking or reversal of the decline in the lake level gave rise to "another very distinct beach terrace about 30 feet lower." These conditions harmonize closely with the evidence of the trees. The oldest sequoias give a record extending back about 3,250 years. They show that about 3,100 years ago a decline of rainfall was arrested and reversed, so that about 1000 B. C. the trees had recovered and were growing at a very rapid rate. This continued, with some fluctuations, till approximately 600 B. C. The period of rapid growth apparently corresponds with the uppermost beach, 60 feet below the outlet, for the presence of such a beach means that for centuries the rainfall was well in excess of that of today. From 600 B. C. to about 200 B. C. the rate of tree growth slowly declined, and presumably the lake did likewise, not remaining at any one level long enough to form a distinct strand. Then increased rainfall seems to be indicated by increased growth, and this continued for two or three centuries not far from the time of Christ. This period would have given rise to Gale's second old shore-line, provided his estimate of 4,000 years since the lake overflowed is correct.

Since the formation of the last main strand—that is, presumably since about 100 A. D.—the lake level has fallen 100 feet. If this process agreed with the variations in the growth of the trees on the other side of the mountain it suffered several interruptions, two of which, culminating about 1000 A. D. and 1350 A. D., were pronounced. Neither, however, was of long duration, especially that of 1350. It may be that, although beaches and other evidences of wave work were produced, they were so slight that they have escaped detection. Another possibility is that the period since the lake last overflowed is "considerably less" than 4,000 years. In that case the water may still have been flowing from the outlet 1,000 or 600 years before Christ, when the oldest sequoias were in their youth. In that case, the strand 60 feet below the outlet may date from the time of Christ, and the next lower one from 1000 A. D. Only the brief rainy period of the fourteenth century will then be unrepresented by a strand.

Without further field-work it is impossible to determine the exact dates of the strands; but this does not affect the main point at issue. Owens Lake, only 50 miles from the Big Trees, must have shared the climatic vicissitudes which they have suffered, while the Caspian Sea, 10,000 miles away, may not have done so. Therefore we discard the use of the Caspian Sea as described in "The Climatic Factor," and substitute the Sierran lake as a guide to the relative climate 2,000 or 3,000 years ago.

This does not change our main conclusion in the least, but merely strengthens it. Unless Gale's figures are in error to an almost impossible degree, the general level of Owens Lake must have been at least 100 feet, and possibly 190 feet, above the present surface for several centuries, at a period not more than 3,000 years ago, and possibly only 1,000. Hence a reinvestigation of the subject in the light of Professor Carter's well-grounded criticism adds strength to the conclusion that two or three thousand years ago, when the largest of the present sequoias were beginning their growth, the climate of the southern half of California and the neighboring desert regions was distinctly moister than now.

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Soil Moisture[1]

The two main factors controlling plant habitats are temperature and moisture. Temperature is uniform, as far as plant requirements are concerned, over wide areas; within any given temperature belt, variations in vegetation may be largely attributed to variations in moisture. This applies even to mountains where, although radical changes of temperature due to altitude occur in short distances, yet within any temperature zone the different kinds of vegetation are due to differences in moisture, whether caused by aspect, by soil, or by the position and character of the underlying rock. Therefore to the forester moisture is of more immediate importance than temperature.

Moisture has a number of phases: atmospheric moisture or relative humidity, precipitation, and soil moisture. Of these probably soil moisture is of the most importance to plants, though the relative humidity, through its effect upon transpiration, often determines the character of the vegetation. The influence of soil moisture is so great that it is considered by many as an integration of the physical condition of the soil. It has even been found by Cameron and Gallagher[2] that the "crit-

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[1] Rotmistrov, V. G.: "The Nature of Drought, According to the Evidence of the Odessa Experiment Field." Translation from Russian. M. of L. and A. Department of Agriculture, I. Shalsky, printers, Odessa, 1913.

[2] Cameron, Frank K. and Gallagher, Francis E.: "Moisture Content and Physical Condition of Soils." U. S. Dept. of Agriculture, Bureau of Soils, Bul. 50, 1908.

Free, E. E.: "Studies in Soil Physics." Plant World, Vol. 14, Nos. 2, 3, 5, 7, and 8, 1911.

Free, on page 36 of the reprint of the above citation, gives briefly the significance of Cameron and Gallagher's work. This work is so full of far-reaching possibilities that Bulletin 50 itself is worthy of careful study by every investigator in forestry, as well as in other lines.

ical" moisture content "is definite and constant for each soil, and that it is closely related to the physical character of the soil." It is safe to say that soil moisture is the most important single factor of the plant's environment, and in many cases the controlling one.

Rotmistrov gives new and startling conceptions of soil moisture. His conclusions are so opposed to the conceptions hitherto accepted that they must, if true, bring about a complete revolution in ideas of soil moisture, particularly concerning the movement of water in soils. His work, although carried on in the steppes of southern Russia, agrees substantially with that of American investigators in the Great Plains.

The American results have never, with one exception,[3] been published; and Rotmistrov's work, though translated into English, is so difficult of access, there being only a very few copies in this country, that it is known to but few. This review is therefore, with the above exception, the first exposition of the new principles published in this country. We are particularly fortunate in that Dr. Shantz very kindly loaned, for the purpose of this review, his own copy of Rotmistrov's work, in which he had made numerous marginal comments based on his investigations in the Great Plains.

The purpose of Rotmistrov's investigations was to determine the causes of drought and the means of combating it. Although he deals almost wholly with cultivated land and artificial crops, yet the principles which he has evolved are applicable to all vegetation growing under conditions similar to those in which he worked. Such conditions are encountered over a large portion of the western United States.

All the works on soil moisture[4] teach us that water rises in the soil by capillarity. The corollary is that as plant roots use the water contained by the soil in which they are growing, more water is brought up to them by capillarity to take the place of that which has been used. The physical basis of this phenomenon, the increase of the capillary pull as the water diminishes, need not be discussed here, being fully treated by Briggs in Bulletin 10 of the Bureau of Soils, and by Buckingham in Bulletin 38

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[3] Burr, W. W.: "The Storage and Use of Soil Moisture." Research Bulletin 5, Agricultural Experiment Station of Nebraska, Lincoln, Neb., 1914.

[4] Hilgard, E. W.: "Soils." MacMillan, New York, 1912.

Briggs, L. J.: "The Mechanics of Soil Moisture," Bulletin 10, Division of Soils, U. S. Dept. of Agriculture, 1897.

Buckingham, Edgar: "Studies on the Movement of Soil Moisture," p. 24. Bulletin 38, Bureau of Soils, U. S. Dept. of Agriculture, 1907.

Free, E. E.: Citation above under Note 3.

Many other publications give similar results on capillarity. It must be remembered that the capillary rise referred to in these works is that found under laboratory conditions.

of the same Bureau. We have hitherto believed that plants depend not only upon the water in the soil layers in which their roots are growing, but also, and more largely, upon capillary water brought up from deeper layers. It is this conception which Rotmistrov attacks for soils at considerable distances above the water table.

Where permanent ground water lies only a short distance below the surface there seems to be no question but that the roots enjoy a continual supply of moisture brought up by capillarity from the water table. The exact distance below the surface at which the water table is of use to plants has never been determined, and will vary with the depth of the roots and character of the soil. In this connection we must also bear in mind that the rate at which the water is moved by capillarity will also be of importance. In heavy soils the capillary rise, though higher than in light soils, may sometimes be too slow to supply moisture as rapidly as it is used by the roots.

The essence of Rotmistrov's findings at the Odessa experiment station may be stated in a single sentence: *Water does not move in the soil by capillarity;* this refers to soils not saturated with water. It percolates downward, but does not return. He ignores capillary movement just above the water table, because the water table is too deep to be of importance. American investigators have found the same conditions in the Plains, where the soil water remains practically stationary, except for downward penetration when more is added on the surface. Burr found that capillary movement was practically nil when the soil was only very little—about 4 per cent—below saturation.[5]

Rotmistrov's attitude throughout the work in question is rather combative. He struggles to destroy old methods which his investigations show to be valueless, and to introduce new ones which he has found effective. His work was done primarily to improve the agricultural practices of the region, and it is his duty to convince men who are probably not as eager to learn as is the average American farmer. This attitude, though not strictly scientific, is therefore pardonable; it does not affect the fundamentals of his work, for his data, based on fifteen years' experimentation, speaks for itself.

He begins with a brief history of methods hitherto advocated for increasing or retaining soil moisture. The accumulation of snow is ineffective, because of the frozen layer, about eighty cm. thick at Odessa, beneath the snow. If this layer thawed only from below the melted snow could get into the soil, but it thaws simultaneously above and below. Direct investigations of many years at Odessa have shown that at the

[5] Burr. W. W.: Research Bulletin 5 (see Note 3), page 76.

period of full thaw there is no rapid movement of water from the upper to the lower soil layers, showing that little snow water finds its way into the soil.

This condition would probably be less true of forests, where the canopy reduces the rate of surface thawing, and gives the frozen layer a better opportunity to thaw from beneath. We know, for example, that in the Sierras of California most of the precipitation comes as snow in winter, whereas the growing season precipitation is light, being even smaller than that of the zerophytic yellow-pine forests of Arizona and New Mexico. Yet the Sierras support mesophytic forests which unquestionably depend largely upon melted snow for their moistures.

He says that deep plowing, "which all writers regard as a matter of great importance in fighting against drought, has very little real significance," and that, to quote Shantz, marginal note, "the effect of manure (is) not known, but (is) not effective against drought."

Rotmistrov does not believe that the selection of drought-resistant plants is a practical solution of the problem of crop production under dry-land conditions, because in wet years the drought-resistant qualities of plants are ineffective and may be lost.

He states that tree-planting as a means of mitigating drought has lost favor in the last decade, quoting a number of Russian investigators who have found that trees "dry up the sub-soil intensively, (and) diminish the ground water. . . ." There have also been failures in tree planting on the steppes. These failures Shantz explains by saying: "Trees die when they become older—due to shortage of water for increased demand." Rotmistrov furthermore says that woods "not only fail to equalize, but quite noticeably increase, the daily variation of temperature" on neighboring fields, citing Wisotzkii as his authority. This is interesting and difficult to account for, particularly in view of Pearson's results.[6] But it must be remembered that the equalization of temperature which Pearson found occurred within the forest itself, whereas Wisotzkii compared temperatures in the open surrounded by woods with temperatures in the open not so surrounded. It is conceivable that the woods in Wisotzkii's work, by hindering the free circulation of air, formed frost pockets.

Rotmistrov believes, however, that single rows of trees would be of some value in drawing water from the deeper layers, which would not be used by the crops anyhow, and adding it to the atmosphere moisture.

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[6] Pearson, G. A.: "A Meteorological Study of Parks and Timbered Areas in the Western Yellow Pine Forests of Arizona and New Mexico." U. S. Weather Bureau. Monthly Weather Review, Vol. 41, pp. 1615, 1629. 1914.

After mentioning briefly the method of investigation, which consisted of taking samples with a "spoon-borer," Rotmistrov comes to the "laws of the circulation of water," the most important part of his publication. In this chapter, most of the first two pages have been underlined and commented upon by Dr. Shantz, and have been corroborated by him.

Rotmistrov's first statement is that the literature of the subject has created a wrong impression that water is raised from deep soil layers by capillarity. By deep layers he means those layers not reached by plant roots, and at a depth of 30 to 70 feet. Shantz's comment is "capillary action does not bring water to the surface."

This disagrees with Free, but agrees with Burr (see above, Note 3). In this connection Burr's table, on page 75 of Research Bulletin 5, is interesting, showing that the rise by capillarity above the water table reached from the 15th to the 9th foot, a distance of only six feet. This distance, though the point is not discussed by Burr, will vary with different soils; but in heavy soils, though the rise will be higher, it will be slower. It is conceivable that, owing to the slowness of capillary action in heavy soils, capillarity may be quite useless to plants, even with their roots near enough to the water table to be within the sphere of capillary action. On the other hand, in light soils capillarity, owing to its more rapid action, is unquestionably of value to plants whose roots penetrate to within short distances of the water table. This matter is not taken up by any of the writers whose work has been seen.

On page 77 Burr presents a table giving the effect of capillarity in soil removed from a supply of free water. This table shows (explanation on p. 76) that the fourth foot was practically dry of available moisture for a year; the fifth foot contained about 4 per cent more water, and was only 3 or 4 per cent below saturation. *Yet no water was drawn from the fifth foot to the fourth foot.* Even in seventeen months the moisture content of these two feet was very little changed.

Rotmistrov next says: "As regards the mechanical raising of water, however, by capillary action, it may be assured that the limit *from which* water can make its way upwards, lies much higher than the limit accessible to roots." Shantz infers from this that "roots move down farther than water moves up." In glass tubes of ten square cm. cross-section, the rise in a very fine soil was 82 cm. in three months, whereas in enclosed wooden boxes 30 x 30 cm. square (900 sq. cm. surface area), the rise in the same period was only 30 cm., or a little over a third of that in the glass tubes. "Even this slight movement," Shantz remarks, "depended on constant head." In the steppe, Rotmistrov says, ground water lies "at a depth of several tens of fathoms;" and Shantz observes:

"Ground water near the surface is not found in great plains as a rule."

In our forests we have practically no data, at least for the west, on the depth of the water table. Does this lie below the reach of the tree roots, so that the trees have to depend on the precipitation which comes from year to year, as do the grasses and many shrubs of the semi-arid regions, or is access to a permanent supply of moisture, as within the limits of capillarity above the water table, indispensable for the growth of forests? Answers to this question must at present be mere speculation; but it seems probable that in open zerophytic forests, such as the yellow pine of Arizona and New Mexico, the trees fail to send their roots down to permanent moisture. The open character of the stand and great root spread are indications of this; whereas in mesophytic forests forming close stands the roots probably enjoy permanent supplies of moisture. Investigations of this point might throw light on many hitherto unexplained openings in forests.

Rotmistrov's experiments in capillary rise, mentioned above, were made in dry soil. In soil which, although without available water, was still not completely dry, the rise would probably be more rapid. Nevertheless, it is highly improbable that, even so, the limits determined in the laboratory would correspond with the limits within which capillarity can make water available to roots. Most important of all, we must remember that, as Shantz remarks, all these experiments depend upon a constant supply of free water. *Soil very little below the saturation point will not lose water to a drier soil by capillarity.* All field tests, both in Russia and in America, seem to prove this beyond question. If such a loss does occur it is so slow as to be negligible, as far as plants are concerned. Dr. Shantz told the writer of a case, the data on which has never been published, of water remaining stationary five feet below the surface for a period of about three years, in spite of the layers above this soil being considerably drier. Burr's example, given above (moisture stationary seventeen months), is another case.

As further proof that capillarity does not bring water to the surface, Rotmistrov shows that after a protracted drought the soil lost water from a compact surface to a depth of only 30 centimeters. Below 30 centimeters no decrease of moisture was observed, such as we should expect to find had there been capillary action—that is, the layers below 30 centimeters gave up none of their moisture to the overlying drier stratum.

"If such a process of moving soil water upwards existed in nature generally," continues Rotmistrov, it could be verified by the diminished water in the layers below those from which the roots had used the water. Fifteen years of observations have shown no such diminution. "It is

only those layers into which roots penetrate that lose water, and the thickness of the partially dried layer corresponds to the length of the roots in the soil." Shantz has underlined this statement as well as the foregoing ones.

Rotmistrov goes on to say that an upward movement of water takes place only in soils saturated with water, thus confirming, in a striking manner, Burr's conclusions for Nebraska (see above). He (Rotmistrov) says that whatever upward transference of moisture there is in unsaturated soils is probably in the form of vapor. Such transference must, we know, be very slow and of small use to plants.

Compression with a roller increases the surface moisture by pressing the soil particles together, expelling the air in the interstices and squeezing a certain amount of water into the upper layers by pressure, but does not bring about capillary circulation. "Packing is of value in germinating seeds, but not in increasing capillarity," is Shantz's comment.

A statement which Shantz has marked "Important," as well as underlined, is: "All the data at my command regarding moisture on the soil of the Odessa experimental field point only to one conclusion, viz., *that water percolating to a depth of beyond* 40 *to* 50 *centimeters,* does not return to the surface except *by the way of the roots.* The italics are Rotmistrov's.

He next shows by actual measurements that "water moves down, but does not come back," as Shantz summarizes it. It appears that at Odessa the water continues to percolate downward, moving at the rate of seven feet a year, instead of remaining stationary, as in the Great Plains. This may, however, be due to the pressure of the water added to the surface. Rotmistrov seems to ignore the point in the moisture content at which capillarity overcomes the pull of gravity and causes an upward movement of water. Apparently, after percolation ceases the water is held fast by the soil grains, there being no intermediate stage where capillarity causes the water to rise.

He also shows that water moves laterally in the soil as well as downward.

In the next chapter he describes "the root system of plants and their rôle in the water régime of the soil." This chapter, though containing less startling material than the foregoing one, still has a number of points worth noting. Perhaps the most interesting part is a series of excellent photographs of root systems. These show the remarkable fibrous network and pyramidal form of the cereals, as well as their length, summer wheat extending down three and one-half feet and corn five feet. The most striking picture is that showing the difference between those portions of

the same root system growing in moist and in somewhat dry soil. The upper portion, growing in "very humid soil," is extremely dense and bushy; the lower portion, in "somewhat dry" soil, is very thin and open. The line between the two portions is sharply marked.

He also shows the effect of black soil versus sandy soil, the roots on sandy soil being less spreading and denser at the bottom. The cause is probably the same as in the case just mentioned—more water in the deeper layers in the sandy soil.

He says that perennials, like green fodder (lucerne) and trees, send their roots down several fathoms—sometimes 10. Lucerne sends a central root down 8 to 10 fathoms, and laterals not over 60 to 80 centimeters. Could not this be due in part to the closeness with which the lucerne is made to grow? The side roots of trees extend 5 or 6 fathoms from the central root, black locust (*Robinica pseudacacia*) spreading even to 10 fathoms. The dense network of the grass roots probably explains the occurrence of grasses on the steppes, since it enables these plants to make the most of the water received.

The next chapter gives the yearly water régime of the soil. The soil is divided on the basis of moisture into three layers: (1) the "*periodically humid layer,*" in which the roots grow, and from which they periodically remove the water; (2) the "*intermediate dry layer*" below the periodically humid one, containing no available moisture, and (3) the "*permanent humid layer,*" with 2 to 3 per cent of available water in the upper part and 7 to 8 per cent in the lower, extending down to ground water. The moisture in this last layer must unquestionably be due to capillarity, though Rotmistrov does not mention the fact. Shantz remarks that there is no "permanent humid layer" in the Great Plains, meaning that it is too deep to be found.

The thickness of these layers, as indicated by Rotmistrov's figures, must vary in different parts of the steppes and in different years. In one place he speaks of "the periodically humid layer" as being 40 centimeters thick; in another as extending down to 100 to 120 cm., and even to 150 cm.; in exceptional cases it may even go down to the "permanent humid layer," giving uninterrupted moisture. In general, the "intermediate dry layer" is between 60 and 180 cm., and the "permanent humid" layer from 180 cm. to ground water. This depth of 180 cm. for the beginning of permanent humid layer seems to be a little inconsistent with the statements in other places of the great depth of the water table, unless at Odessa the water table lies at considerable distances below the upper part of the "permanent humid layer."

"Every year, at the end of June or beginning of July—and with a dry spring season at the end of May—our cereal grasses consume all the reserve water which has accumulated in the whole thickness of the root-inhabited layer during autumn, winter, and spring." Rotmistrov has italicized and Shantz underlined the above statement. There is no difference between wild and cultivated plants; by midsummer the entire reserve of available water is exhausted. The same condition is seen in many parts of our West, where the grasses dry up, forming a natural hay which remains on the stalk.

On waste land the yearly balance of water is less than on "old plowed land." Shantz explains this by saying that "waste land probably means land with weeds, and is dry because of these (the weeds)." The permanent moist layer is 14 to 30 feet deeper on waste than on cultivated land, a fact which Rotmistrov attributes to the raising of the "permanent moist layer" by cultivation, though giving no reasons. Shantz makes the following interesting comment on this paragraph:[7]

"A condition similar to this would be found on the Great Plains in case the temporary moist layer (Rotmistrov's 'periodically humid layer') became so thick that plant roots could not reach through it. The water thus left below the root layer, and consequently lost to the crop, would probably remain as a permanent moist layer, but would not be in contact with the ground-water level. I know of no permanent humid layer under cultivated plots at Akron (Colorado), and such a condition is not general on the Great Plains."

This is but natural on the plains, where the water table is too deep to be found. But it is reasonable to suppose that cultivation would increase the proportion of water which enters the soil: in the first place, the roughness of cultivated land would permit less run-off, and, secondly, its looseness would permit more water to soak in.

Rotmistrov explains the failure of perennials and trees in this region by saying that the roots, being unable to live in the "intermediate dry layer," fill up the "periodically moist layer," quickly use up the reserve supply of water, and die. He says that perennials require a humid layer as deep as the whole length of their root system. Shantz remarks that this is "not true of drought-enduring plants."

A striking feature of this chapter is the series of diagrams graphically representing the water régime for the year; each diagram shows, by shading, the water at each depth for each month. Thus the moisture conditions for the entire year can be seen at a glance.

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[7] In a letter which Dr. Shantz very kindly wrote giving suggestions for this review.

The first diagram (fig. 10) shows water in only the upper 35 cm. of soil during the winter, the frozen layer preventing downward penetration. At the end of April the drop characteristic of the spring thaw occurs, carrying the water 10 cm. further down. The crop in this case happened to be barley, which requires a moist layer 110 cm. thick, and used all the reserve moisture before the middle of May. The crop would have died had not the growing season been unusually moist, with 68.4 mm. of rain. Even then the crop was poor, showing that "the thickness of the humid layer in spring at seed time is of final importance, if there is not plenty of rain later on."

Another diagram shows the downward percolation of water which had reached a depth greater than that of the frozen layer before winter began.

The main fact which stands out in all the diagrams is that, notwithstanding varying amounts of reserve water at the beginning of the growing season, all this reserve is exhausted by midsummer. Sometimes, when the reserve is large, it lasts till July, or even August; when small it is gone by May or June. He shows later that with certain shallow-rooted crops, such as potatoes, there may be a layer of moisture left below that used by the roots.

The next chapter is devoted to methods of soil management best suited to avoiding drought. The keynote of this chapter appears to be that crops should be rotated according to their root systems and demands upon soil moisture. Cereals which are deep-rooted and heavy users of water should not be grown constantly, even though different cereals are used. The aim should be to rotate deep-rooted crops, shallow-rooted crops, and bare fallow. His ideal appears to be a four-course rotation, consisting of fallow, winter wheat, potatoes, and barley, the potatoes, on account of their shallow roots, leaving some moisture for the barley. He emphasizes the importance of not wasting any water on weeds and keeping the ground clear of them.

At the end of this chapter Rotmistrov assembles the conditions preceding drought. These are: (1) a part only, instead of the whole, of the root-inhabited layer being moist at the time of spring sowing; (2) chronic perennial dryness beneath the periodic humid layer; (3) extreme depth of ground water. Shantz has underlined the above numbers, and remarked "Conditions on Great Plains."

The work of Rotmistrov and that of American investigators points to the conclusion that *soil water below the field-saturation point, and uninfluenced by the water table, does not move by capillarity, but remains, for all practical purposes, stationary* until used by plant roots or pushed downward by the addition of more water from above.

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Seed Production of Western White Pine [1]

This is the first publication of its kind in this country, and marks a distinct advance in the science of American forestry. Collection of accurate information on seed production of different species is one of the most important subjects for the forester to take up; and yet, up to the present, has been chiefly confined to superficial observations. The reason for this is that the subject furnishes a number of highly complex problems, all of which necessitate detailed scientific investigation separately for each important species. The bulletin indicates the following four distinct problems in seed production of forest trees: (1) "The determination of the amount of the seed crop;" (2) "the determination of the periodicity of seed production;" (3) "the determination of the various external and internal factors which affect the amount and the periodicity of seed production," and (4) "the solution of the biological problem of seed production." The solution of these main problems involves a great number of complex minor problems, which should be clearly outlined in some future bulletin.

The bulletin deals directly only with the first of these main problems—that is, method of measuring seed crop as applied in 1911 to the study of the seed-bearing characteristics of the western white pine in Idaho, on the Kaniksu and Cœur d'Alene National Forests. It includes detailed summaries of the results of measurements on the four sample plots which comprised the field-work for the study and a résumé of important facts and conclusions derived from the plots.

The method employed in the investigation is the sample-plot method,[2] which consists in determination of seed production per acre, for a given forest type (in this case comprising 80,000 acres), by means of detailed measurements on a few small sample plots (in this case including three sample plots of one-half acre each and one of nine-tenths of an acre). The following data were collected on each plot:

1. Trees divided into five crown classes—(I) dominant, (II) codominant, (III) intermediate, (IV) oppressed, and (V) suppressed—the crown class and diameter of each tree tallied; note made in regard to each, whether seeding or not.

2. One to three sample trees, of trees actually bearing seed, were cut for each crown class which participated in the seed production of the stand. Classes IV and V in no case bore seed, but three trees of these

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[1] Bulletin 210 of the U. S. Department of Agriculture, by Raphael Zon.

[2] See Proceedings Soc. Amer. Foresters, Vol. VI, No. 2 (1911), article by Raphael Zon and C. R. Tillotson on "Seed Production and How to Study it."

classes on one plot were also cut to secure data on their age, rate of growth, etc. A total of 24 seed-bearing trees were cut on the four plots to represent a total of 140 trees which bore seed; 217 trees (or 60 per cent) bore no seed.

3. Total height, age, health, and the number of cones and their lengths, volumes, and green weights were determined separately for each sample tree. Subsequently the amount of clean, germinable seed was determined separately for each tree by germination tests. From this data on the sample trees was then determined the total seed production of each crown class per plot and of each crown class per acre and of all classes per acre.

Variation in seed production in the individual trees is shown by the following figures from Plot I, and emphasizes the importance of taking several sample trees, in order to get the average seed production for a given class of trees which bore seed, and the utmost care which must be taken in selecting trees as a basis for these averages.

Crown class.	Diameter.	Age	Height.	Weight of clean seed (grams).
I	28	230	166	330
I	28	230	152	59
I	21	223	147	26
II	24	215	154	40
II	21	200+	146	5
II	21	200+	152	94
III	14	200±	104	13

There is every reason to believe that the seed production on the four sample plots was determined with sufficient accuracy. The chief question arises in regard to the accuracy of applying the yield from these plots to an area of 80,000 acres, in order to determine the total yield on the same. The variation in per acre seed production of the four plots was as follows:

Plot 1, 5.4 pounds, 185,000 seed.
Plot 2, 2.5 pounds, 68,000 seed.
Plot 3, 0.6 pound, 17,000 seed.
Plot 4, 2.9 pounds, 74,000 seed.

This leaves much leeway in the possible application of the results to 80,000 acres. Unfortunately there is no silvical description of the different sample plots in the bulletin, nor is there any description of the 80,000 acres of western white-pine type, including variations in char-

acter, average diameter and number of trees per acre, etc.; so there is no basis for judgment in regard to the correctness of the application. On the other hand, it would probably be an unwarranted expense to have taken more than four such detailed plots for seed-production determination on a limited area of 80,000 acres.

This brings up the question of the relative merits of the sample-plot method as compared with the so-called "volume-table method."[3] The latter method involves the construction of "seed-production tables" primarily to show the average production of trees of different diameters and crown classes (and very possibly for several age classes) during good, medium, and poor seed years. Thus the same year for the same species in one locality the figures for good production might be applicable, while in another locality (due to slight seasonal or other differences) the figures for poor production would be the ones to use. Secondarily under the method would be considered the influence of age, character of site, degree of health, and the effect of opening up the stand by lumbering, etc., upon the average seed production of individual trees of different diameters and crown classes during good, medium, and poor years. The basis for such seed production volume tables could well be secured by using methods identical with the excellent ones employed by Mr. Zon in his sample-plot study, as in each case he accurately determines the seed production of individual trees (sample trees), which have been elaborately described in regard to crown class, diameter, age, height, health, etc. In fact, his conclusions and data in regard to seed production of individual trees may prove to be the most valuable results of his study, because they furnish possible bases for developing the seed-production, volume-table method. The most important of these, as given under his résumé of conclusions, are the following:

1. Perhaps the most striking fact brought out by this investigation is that the different crown classes do not participate equally in the production of seed. Thus 98.8 per cent of all the seed in 1911 was produced by the first two crown classes, while the third contributed only 1.2 per cent. It is interesting to note that though 1911 was a year of a moderately good seed crop, the crown classes IV and V did not bear any seed at all.

"The participation of the different crown classes in the production of seed may serve as an index of the seed crop. In exceptionally good seed years not only the dominant classes bear seed, but even the oppressed trees have occasional cones, while in poor seed years cones are to be

[3] See Discussion by S. T. Dana in Vol. VII, No. 1, of the Proceedings, on "Seed Production and How to Study it."

found only in the dominant class (I), and even then not on all trees or parts of their crowns. Between these two extremes range seed crops of various abundance. The abundance of the seed crop can therefore be prognosticated very early in the summer by observing in the forest the kind of trees that bear cones.

"2. The largest amount of germinable seed was invariably produced by trees chiefly of the first and also of the second crown class. The largest amount of germinable seed recorded (2½ ounces) belonged to two trees of crown class I, and in only one case has this amount been closely reached by a tree of crown class II. Crown development thus seems to be the most important factor in the seed production of trees.

"3. The age of the trees evidently has an effect upon the amount and quality of seed produced. Thus the younger trees (in plot No. 4), ranging from 72 to a little over 100 years in age, have produced practically in all three crown classes a larger quantity of germinable seed than the older trees. Apparently the age has also something to do with the average length of the cones, since the younger trees possessed, on an average, longer cones, which yielded a larger number of pure seeds per cone than the older trees. The germination percentage was also greater in the younger trees than in the old ones; the highest germination percentage reached (90) was found in a tree 72 years old, while the highest found in the older trees was 67.5.

"4. The relation between the length of the cone and the size of the seed (the number of seed per pound) is clearly shown. Thus the longest cones, 8 inches and over, yielded about 22,000 seed to the pound, while cones 5 inches long occasionally yielded as many as 57,000 seed to the pound.

"5. The vigor of growth apparently influences favorably the amount and quality of seed produced. Thus trees which grew at the rate of 0.19 of an inch in diameter and about 1.25 feet in height annually produced a larger amount of germinable seed than trees which grew at a slower rate. This, however, may be indirectly the effect of the age of the tree, since the younger trees have not yet passed the period of most rapid growth.

"6. While a relation between the size of the seed and its germinative vigor is not clearly brought out, yet there seems to be a tendency for the larger seeds to have the highest germinative vigor.

"9. Since the size of the cones goes hand in hand with the weight, the following generalization may be made: The larger or heavier the cones the larger is the seed, and the larger the seed the greater is the germina-

tion percentage; therefore, the larger the cones the better is the quality of the seed. This is of importance in seed collection."

W. D. STERRETT.

FOREST SERVICE,
WASHINGTON, D. C.

REQUEST FOR PROCEEDINGS

A copy of Vol. VIII, No. 3, of the Proceedings of the Society of American Foresters is desired by the Commission of Conservation, Ottawa, Ontario, Canada. The Commission is prepared to pay a premium for the number, the supply of which is exhausted at the office of the Society.

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Society of American Foresters

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CONTENTS

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Papers that have already appeared elsewhere will not be accepted for publication. Simultaneous publication in another journal will not be agreed to.

Manuscripts may be sent to any member of the Editorial Board and should be clearly typewritten and in suitable form for printing without essential changes. Footnote references should be complete, including year of publication.

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Robert Langdon Rogers

ROBERT LANGDON ROGERS was born in Westerly, R. I., October 12, 1883, and died of acute pulmonary tuberculosis, in Providence, R. I., May 25, 1915.

Rogers entered the Academic Department of Yale in the fall of 1902. Late one night in his sophomore year, as he was on his bicycle "heeling" for the *Yale News,* he was struck down by a trolley car and received serious injuries from which, it may be, he never fully recovered.

Rogers was much beloved by all his classmates for his quiet dignity, his gracious manner, and genial nature, combined with an earnestness of purpose and high ideals. He was elected to the Elihu Club in junior year.

Rogers entered the Yale Forest School with the class of 1908, and there was loved and respected as he was in the college. He was made president of the Forest School Club. In his Forest School course he worked with zeal and enthusiasm. Between junior and senior years he was chosen to be the forester for Prof. Isaiah Bowman's expedition across the Andes from Peru to the headwaters of the Amazon. His modesty was such, however, that only his most intimate friends heard of his adventures on this expedition.

Rogers' health during his last year at the Forest School, though apparently not affected by his accident, was none too robust; but his nature was so uncomplaining that even his closest friends could not tell when he was ill.

Upon graduation Rogers entered the Forest Service and was assigned to District 3. After two years of valuable work as planting specialist in the district office, he was assigned to the Coronado National Forest, with headquarters at Tucson, Arizona, and was soon promoted to be deputy supervisor. After this he spent a year on working up lumbering data. At this time his health began to fail, and he was transferred to Washington in editorial work. His health, however, hindered him greatly, and in 1914 he left the Service.

The loss of a man with such high ideals, such devotion to his work, and with such a lovable personality will be keenly felt by all who knew him.

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THE NEED OF WORKING PLANS ON NATIONAL FORESTS AND THE POLICIES WHICH SHOULD BE EMBODIED IN THEM

BY PROFESSOR BURT P. KIRKLAND
University of Washington

This article is written with the frank purpose of helping to convince the profession, particularly that small section of it so situated officially as to be able in the main to put in force on the National Forests such policies as it wishes, that some radical changes are desirable in those policies so far as they relate to the timber resources. To avoid any misunderstanding on the subject, the writer wishes to affirm at the start that he is in strong sympathy with the National Forest policy, even to the extent that private lands within and adjacent to the boundaries should be purchased, but believes it should be modified in some important details, as will appear hereafter in this discussion.

The phases of the subject dealt with here will consist in the main of two: (1) Should National Forests have detailed working plans? (2) What main policies should be provided for in working plans? The first question can be quickly disposed of.

SHOULD NATIONAL FORESTS HAVE DETAILED WORKING PLANS?

This is a fair question, meant in no spirit of facetiousness. If some foresters gave their true positions on the subject, they would answer, "No; working plans hamper freedom of management, and are an inconvenient bar to doing as we choose without explanations." For example,

if a lumberman offered a good, round stumpage price for a billion feet of timber where that amount would constitute practically the whole stand, it is evident that any working plan would be likely to provide against such sudden removal of the entire stand, and would constitute a bar to "practical" management. Not a few foresters, on reaching the field, find that not all the teachings of the schools can be applied at once; whereupon they discard all, and become as "practical" as the lumberman. They fail to note the differences in business management which must be introduced as soon as the forest is handled as a permanent producing unit, rather than like a mine, which is the method adopted by the lumberman. Under the latter method, one thinks of the forest as so much standing timber to be cut right away, or held, whichever may be more profitable. If such a forester has gained the public point of view a little, he will advocate holding the mature timber to "increase the future timber supply." It is believed that only foresters of these views would declare against working plans entirely.

Such arguments as are introduced here are addressed to those who believe forest organization can be of help today. To these, only brief argument is necessary to show that the written plan is the only adequate way of preserving the work of one forester for his successor, or even the work of a single forester for his own use in future. It is now axiomatic in scientific management of industry that the best methods must be reduced to writing, and means taken to see that these written instructions are carried out. If this is necessary for those tasks which are repeated many times daily, how much more necessary are written plans covering work which takes years to perform. The necessity for written plans covering the work for years in advance is, in fact, recognized by the Forest Service, and firmly insisted upon for permanent improvement work, regulation of grazing, and in fact nearly everything except timber—the main forest resource. In the case of the timber, the plans have been of the most elementary nature. The strongest reasons for the making of detailed working plans can be developed, however, only when the policies which are to be laid down in them are considered. Such considerations must lead to the conclusion that if these polices are to be carried out efficiently, more or less detailed plans must be made. These policies will be next considered.

FUNDAMENTAL POLICIES WHICH SHOULD GOVERN WORKING PLANS

Is an approximately annual sustained yield applied to producing units of, say, 50,000 to 500,000 acres, the best for National Forests? It would undoubtedly be unnecessary to ask this question in any other country

making a pretense of forest management. In an article previously published,[1] the writer assumed that this would be taken for granted, but subsequent events show that it was an error to assume that there was any considerable sentiment, at least in places where it could be effective, toward handling the National Forests in this way. Since this is a fundamental question, to be solved before any working plan can be made, consideration should be given to it. There is such an overwhelming mass of arguments for this method that most of them will be cited only briefly. To do more than this would waste space; for any one of several lines of argument is sufficient to convince where any conviction in this direction is possible. In the article cited, the writer pointed out some arguments in favor of sustained annual yield by large watersheds, which are generally producing units. Moore advocates the market unit as the proper unit of regulation; but as this term is a loose one, the writer prefers the term producing unit. Some of the well-known reasons for sustained annual yield are: (*a*) Sustained annual yield keeps forest conditions constant as to amount of cut-over land, young and old forest on a watershed at all times, and hence tends to keep stream-flow constant wherever the forest has any influence in this respect. (*b*) Without an approximately sustained annual yield, permanent transportation systems cannot be maintained; hence neither early thinnings nor small areas of fire-killed or insect-killed timber can be utilized. As a result, the financial returns can hardly be as great. (*c*) Protection against fire and insects is far more difficult on vast even-aged areas. The future will not hold forest managers of the present day blameless for disregard of such serious matters.

Space, however, does not permit full discussion of the foregoing points, and in fact this should not be necessary. This phase of the discussion will be limited to the three following items: (1) Sustained annual yield gives the best social results. (2) The forest organized for sustained annual yield is in the best form as an investment, if not the only suitable form. (3) The forest organized for sustained annual yield is the safest against mismanagement. These will be taken up in order.

(1) *Sustained annual yield gives the best social results from the use of the forest. By this is meant that it contributes to those living conditions that are best for the physical, moral, and mental welfare of the persons directly affected.*

The lumber industry is a great industry, with a clean record in many of those things which have been the shame of American industrial life.

[1] Burt P. Kirkland. Working Plans for National Forests of the Pacific Northwest. Vol. VI, No. 1, Proceedings of the Society of American Foresters. May 1, 1911, Washington, D. C.

It has, for example, never practiced the wholesale displacement of the American workmen by whatever foreign labor was cheapest, and it has never been a great factor in forcing down wages, except in certain limited localities. It has, however, one great shame, due to no fault of the small competing units making up the industry, but rather to the economic conditions under which these units have worked, and must continue to work for some time to come. As long as the industry is organized on such a highly competitive basis, these small units will be helpless in this respect except under conditions pointed out hereafter. The reproach that remains against the industry is its influence on the labor engaged. The "lumberjack" may be a more or less attractive figure in literature, but few will affirm that he is a strong factor in the upbuilding of American citizenship with a high mental, moral, and physical endowment. The reason for this lies in the fact that normal family life is impossible to the majority of employees in the industry, and in the few instances where marriage is possible the conditions are almost impossible for the proper rearing of children. Investigation of labor conditions in Washington by Mr. Stewart Rice shows that only fourteen per cent of employees in logging camps are married.[2] The same author states that "the laborer who follows the logging camps must be single and homeless. If he has not the instincts of a rover to begin with, he must acquire them." The writer has had called to his attention and has personally known many specific cases where men reared on farms or under other influences of like nature have gradually become degraded until the call of "wine, women, and song" became so strong that no job was held longer than was necessary to get a five or ten-dollar stake for a return to the city. That a large portion of the workers in the industry have fallen into this class is so well established that the policy of many cities in the lumber regions in regard to "wide-open-town" policies is fixed by this consideration. Business men claim that prohibition of alcoholic liquors and of the social evil will divert the trade of these classes from the city that enters upon such prohibition. Not only, then, are many employees in the industry degraded by the condition under which they work, but civic morals are corrupted. It is, indeed, impossible to say how far the influence of these wretched conditions extends. As to the few married employees, it may be said that a shack in a temporary logging camp or sawmill town is hardly the place to rear children with ideals looking toward a higher plane of life. That a chosen few can live through these conditions and make marked success is no argument in favor of its continuance.

[2] Stewart Rice: Thesis, 1913, University of Washington, p. 69.

This brief review of labor conditions in the lumber industry will serve to call to every one's attention the facts as they are, and it is felt that this will generally be admitted to be a true picture. The question is, Why are these conditions present in the American lumber industry, and what have they to do with forest management? The answer is that these conditions are caused by the transient character of the industry. Large areas are cut over in haste, and the industry moves on to other fields. Nothing but temporary, more or less sanitary, camps or shack-towns can be built under this management of the forest. Few laborers who choose the logging industry will ever live in a permanent house. We do not hear of such conditions in Germany, where forests are handled under approximately sustained annual yield. We shall do away with it in America when sustained annual yield is practiced in our forests. It is not sufficient to practice sustained yield. It does the laborer no good to know that the area he is cutting over will yield another crop in 80 to 100 years. It does benefit him to know that cutting is so regulated upon it that within reach of his home there will be cutting going on indefinitely. Only the forest organized for sustained annual yield makes the permanent home and family life possible for the woods laborer; and, in the words of Jacob Riis:[3]

"Imagine a nation of homeless men, a nation that deserves the epithet, 'the homeless people'; what would it have to preserve, what to fight for? And however given to peace we all may be, in the last analysis, the test of a nation's fitness to live is that it will fight for its life. No! Wipe out the home, and the whole structure totters and falls. Even if it hang together yet a while, it is not worth preserving, nor worth fighting for."

It may be a fact that some readers of this article will think that any care of the working classes is of no moment—that they only exist to produce and yield profits to the "upper classes." Although the writer has no interest in addressing any argument to this class of readers, he feels sure that even they will in the not-distant future change their minds on this point. Many business concerns have done so for business reasons. National interests demand care of the laborer. England has, for the most part, neglected this care, and good authority now states that only 1 in 22 of her population is now fit to bear arms. Germany has cared for her laboring classes, and 1 in 7 of her population is worth training for the army. The United States has had no recent occasion to take account of stock, but since she is even behind England in protection for the working classes, any cause for congratulation on better conditions is due only to her superabundant natural resources.

[3] Jacob Riis. "Peril and Preservation of the Home," p. 20.

Whether the foregoing arguments have been so presented as to carry conviction, the writer is unable to judge, but he feels certain that any reader who gives this phase of the subject careful thought will inevitably reach the same conclusion—that the average employee in the lumber industry can never have a permanent home until approximate annual sustained yield management of forests is practiced, and that care of the human resources of the country is so important as to prohibit any other type of management where this type is possible. Such management is possible on the National Forests of the Pacific Northwest at present, because areas which can be worked from a single center will yield as high as 20,000,000 to 30,000,000 feet board measure of timber annually for indefinite periods. It is no doubt possible on most other National Forests, because horse logging does not require large annual yields in single localities. Outside the National Forests, private ownership and the economic conditions surrounding it do not permit of sustained-annual-yield management.

A beginning in this work rests, then, directly on the Forest Service. The man, whether forester or not, who believes that the human resources of the nation are important above stumpage prices cannot escape some bitterness of feeling when he sees the Forest Service handling its timber-sale policy from much the same viewpoint as would be expected of a lumber trust—that is, determining whether each specific sale of any size shall be made almost wholly on the basis of price. It is useless to point to official publications to prove that "all mature timber is for sale when it can be spared from the forest." It cannot be denied that because white pine will bring $4 to $5 a thousand in Idaho it is sold, or that because Douglas fir is worth only $1 in many localities in the Cascades it is not sold. The fact that the sale of a large tract in Idaho may overcut the forest unit where it is sold seldom prevents the sale, nor does the fact that the Douglas fir in Washington is overmature and rapidly deteriorating insure its sale. High prices for yellow pine anywhere will apparently secure any tract, from a watershed to a National Forest. (Witness the Kaibab.) If it can be shown that any of these statements do not represent the facts, it is certain that such a showing will relieve the fears of many foresters, both inside and outside the Service. Should it be felt that this criticism indicates that any blame may attach to the Forest Service for these conditions, the writer is well aware that two explanations in particular can be offered. The first is that this is the best financial policy, which admits at once that the dollar is placed above the man in this branch of the Service policy. It can also be shown rather conclusively that this is *not* the best financial policy. The second explanation is that

the Forest Service needed immediate income to appease Congress. Since the writer knows, from his own experience, of sales in overmature, deteriorating Douglas fir to the value of hundreds of thousands of dollars lost by the Service through a policy of delays, negation, and price demands beyond the value of the timber, and has heard plenty of good evidence that similar conditions have been found elsewhere, he denies this explanation any validity.

It seems reasonably clear that the policy is not due to willful neglect of the human side, because when the relations are clear this side has been carefully considered in Forest Service grazing policy, in free use of timber, in small timber sales, and special uses. Only in the large timber sale policy has this factor been entirely neglected, though it is likely that it will affect more people vitally than does any single one of the policies above mentioned. This policy apparently rests on a point of view in all respects similar to that of the timber speculator, but without his justification, because there is neither public nor private gain in it (unless for the timber speculator whose stumpage prices are boosted by this policy). The writer has never yet shared the belief, which is quite common in the West, that the Forest Service intentionally holds up prices for the sole benefit of the large private stumpage owner. The policy, in his opinion, rests mainly on a fallacy which will be dealt with later, viz., that withholding the cutting of mature timber now will increase the timber supply of the future. Lately some idea has come in of helping the lumber industry by preventing overproduction.

The fact still remains that only sustained-annual-yield management yields the best environment for all kinds of employees in this branch of industry. Without permanent homes and family life, with efficient schools and environment such as to permit it, the highest development of the individual will continue to be impossible.

Agriculture is noted as an industry from whose ranks our cities constantly renew their population and receive many of their leaders; but has any one ever heard this to be true in any great degree of the lumber industry? Yet its work calls its employees into the great outdoors in even more healthful surroundings than agriculture. The writer refuses to believe that the lumber industry, which nominally should be one of our most helpful industries on the human side, cannot be reorganized along necessary lines. He will continue to affirm that the Forest Service should be a leader in this reorganization. Representing public stumpage holdings, it should be the very first to give stability to that section of the industry (about one-fifth of the total) which it controls. If democracy cannot enforce industrial conditions which make for upbuilding of the nation, instead of decay, then it is self-destructive.

(2) *The forest organized for annual sustained yield is the best form for investment, if not the only suitable form. Following are some of the reasons why this is true:*

(*a*) While a permanent investment is the best investment, other things being equal, only permanent investments which give annual or nearly annual returns are really desirable.

(*b*) Only the forest organized under sustained annual yield meets the requirements of annual income. In the case of the large owner, as the Federal Government, the scattered ownings largely meet this requirement as to income as a whole, but it is still necessary to bear this fact concerning smaller tracts in mind in taking up principle (3) later in this discussion. Moreover, the Federal Government cannot properly assume that it will be the permanent owner in all cases. If it does not shirk manifest duty, each forest tract will be handled in the best way to meet needs of any form of ownership, whether Federal, State, municipal, or private.

(*c*) Without sustained annual yield permanent transportation facilities cannot be maintained, and without these most thinnings will be impossible, as will also the salvage of insect-infested or fire-killed timber. In few, if any, of our forest tracts will maintenance of permanent transportation facilities be possible unless there is at all times mature timber being utilized. This condition occurs only in the forest under sustained annual yield. In the periodic-yield forest mature timber is not available at all times, and permanent transportation facilities are seldom possible. Thinnings will be needful during periods when adequate transportation facilities are not available. The thinnings, therefore, cannot be made at such times, with the result that the material will be lost, together with the benefit to the stand. Likewise small areas of fire-damaged, insect-attacked, or windfall timber will have to be left in the woods to create more danger from fire or insect damage or be removed at heavy expense. Thinnings have a far greater influence on the wood supply of the people than they do on the financial returns to the owner, hence they are more important than the latter indicate. Financial results are, therefore, much poorer in these ways, both because of diminished receipts and increased expenses. This discussion applies today, because in parts of the Pacific Northwest profitable thinnings can be made today in stands forty years old or more, where within a short distance of transportation. Let it not be said, then, that thinnings are something for the distant future, any way, and need not be considered in management today. On the North Pacific coast, and probably in the Idaho white-pine regions, yields from thinnings will be of far more volume than final cuttings on the

bulk of the Rocky Mountain forest areas; so thinnings need not be scoffed at. The advantages of sustained annual yield mentioned under this head are so well known as to require no further discussion.

(*d*) *Even the utilization of the present stand will in most cases yield the best financial results under a sustained-annual-yield policy.* This point deserves full discussion. It depends very largely on the fact that *depreciation of plant is one of the heaviest, if not the very heaviest, capital charge in the logging and milling of timber.* The competitive system incurs the highest possible depreciation charges because of the unnecessary multiplication and consequent short life of plants. The Forest Service is a keen believer in this system, as may be seen, curiously enough, under the heading, "Stable Industries Encouraged." "In the management of watershed or other units, the construction of new and competing mills will be encouraged to such a number as can operate for a reasonable period in accordance with prevailing standards in the industry. A number of small mills is always preferred to one or two large plants."[4] Instead of encouraging stable industry, this absolutely insures continuance of unstable industry. Passing over the inference that prevailing standards are considered sufficient by the Forest Service, it is desirable to inquire what the effect of this policy must be on the cost of manufacture, and hence on one or more of the following: Profits to the mill owner, stumpage prices, or prices to the consumer.

One or the other of these three items is affected by every element of manufacturing cost. Although the statement quoted leaves us in doubt as to what is a "reasonable period" for a mill to have a supply of timber to operate upon, from other statements and from practice of the Service we can confidently infer that 5 to 15 years is considered to be such in most cases, and 20 to 25 years in very extreme cases. Taking 10 years as a fair average, it is obvious that all logging and milling plants must be depreciated to junk value in that period. Since the junk value will be small, the depreciation will closely approach 10 per cent; and since the average mill, if at all well equipped, will cost perhaps $2,000 per thousand feet daily capacity, and the logging camp $1,000, a total of $3,000 per thousand feet daily capacity, 10 per cent depreciation on this means $300 annual charge against the output of the plant for each 1,000,000 feet daily capacity. On the basis of 300 days' operation in a year, the depreciation charge will be $1 for every thousand feet output of the plant, even if it operates continuously. If competition forces additional shut-downs, the depreciation will be greatly increased. It

[4] National Forest Manual, p. 14–S.

should be again recalled that there are only three sources from which this may come, viz., from stumpage prices, the investor, or the consumer. According to Forest Service theory of stumpage appraisal, it must be deducted from stumpage prices. That is why this unnecessary rate of depreciation caused by putting in too large or too many mills reduces financial returns, as compared with annual sustained yield management, or the nearest approach to it. These mills which are depreciated in 10 years depreciate chiefly because of exhaustion of raw material rather than wear and tear or obsolescence. Some machinery items may depreciate in 10 years by wear and tear, but properly constructed mill buildings will last 30 years or more, and railroad grades indefinitely. An average life of 25 years on the bulk of the plant may be safely assumed. This means only 4 per cent straight-line depreciation if a plant is built of only such size as to make the timber last 25 years at any one cutting. Depreciation will be further reduced under sustained annual yield, because some items, such as railroad grades and other grading, never depreciate if maintained even as temporary grades must be. Furthermore, there is no time in the case of a mill fit to operate, although it may have been in operation 25 years, that there is not a great amount of value in the mill and yard equipment which will be conserved if operations continue in the same place, and lost if they are discontinued. But even assuming 4 per cent depreciation in the case of the long-time operation, the depreciation charge would be only .04 x $3,000, or $120 per thousand feet daily capacity. Spread over 300,000 feet per annum, this amounts to 40 cents per thousand feet output—a very important saving where compared with the $1 depreciation charge resulting from a 10-year depreciation period. Total savings in depreciation by the long-time operation, as compared with short periods, will vary according to the length of the latter. They may be greater or smaller than the example above.

It has not been overlooked that a plant of efficient size must be established, and that localities exist where a small plant operating for a short period is all that can be expected. In such cases the more or less portable mill is in order, and these small tracts should be handled for management purposes with others, so that even here there is no undue depreciation charge, each plant being assured of practically permanent operation. The writer does not know personally of such tracts, but believes there are such. He does know of valley after valley in western Washington where one or more mills of efficient size could be operated permanently if the Forest Service cared to handle the timber on that basis. One valley that can be cited would yield in the neighborhood of 30,000,000 feet board measure per annum indefinitely, which would operate a mill of

100,000 feet daily capacity 300 days per annum. If the mill were properly located, the very longest haul for logs would not exceed 15 miles—nothing unusual, even today, in logging practice in this region. Sustained annual yield here will be far better business practice from the standpoint of utilization than will periodic yield, because the mill and logging investment under sustained annual yield would be the *minimum possible*, and, being for a long time, would call for the *lowest interest rates* and *bear lowest depreciation*. Hence the charge per thousand feet cut would be the lowest possible for interest and depreciation. The stumpage prices could, therefore, be the highest possible, or the consumer get the product at the lowest possible price, and still give the investor a fair return. As a matter of fact, however, there is no question whatever that any person who will offer a good price for the timber in the valley cited can buy one-quarter to one-half of the timber. Officers of the Service would further be pleased, if by putting in three to four times the plant necessary if worked on sustained annual yield, the whole valley is logged off in 10 years, although the capital charges per thousand feet would thereby be greatly increased. Since this valley is fairly accessible, and only the reluctance of the Service to sell for less than $2 per thousand feet in this region, together with some other small points of policy, prevented large sales on at least two occasions in the past, the writer expects in a few years, unless present policy changes, to report that this valley has been stripped as indicated, and the possibility of entering upon a sustained annual yield management deferred for 80 to 100 years.

In an adjacent valley, two mills dependent on National Forest timber have been located within a mile of each other, so as to be dependent upon exactly the same body of timber. One of them is temporarily closed, due to financial difficulties, but there is small reason to suppose that these would not clear up shortly, especially with some encouragement from the Service. Since one of these mills could have cut all the timber within easy reach within its natural life, the capital put in the other plant was almost entirely wasted. Somebody—either the investor, the stumpage owner, or the consumer—must bear this loss. According to Service stumpage appraisal theory, it must come out of stumpage. In view of these instances, we must regretfully conclude that though rushing off the timber on a given tract in a short time is financially suicidal—even from the standpoint of utilizing the present stand—the Forest Service is not aware of this fact, or the policy would be changed to sustained annual yield or the nearest practicable approach to it.

There remains still further evidence under the heading of financial savings in utilization of present stand. When the wood-using industries

once understand that the fixed purpose of the Service is to work every producing unit on sustained annual yield, the logical place for many small wood-working industries would be on the National Forests, oftentimes near some sawmill, where slabs or wood waste now of no value could be secured, not only today, but during the life of the plant. At other times these industries would use the whole tree. Numerous locations for stave mills, mechanical pulp mills, and small wood-working industries of all kinds could be found superior to locations in the cities, not only because of cheap raw materials, but because, with the possibility of building permanent villages near perpetual sources of raw material, comes the opportunity to have a labor force living under healthful surroundings, and hence of a character in which efficiency can be built up and maintained. Such industries would probably be more plentiful in the hardwood regions of the East, but some could be secured in the West today. All of these would contribute to the financial returns from the present stand, because constituting (in many cases) a higher use than lumber.

Organization along these lines will take "management that manages;" but this is what we have in efficient private concerns, and have a right to demand from the Government.

As a matter of fact, the forests of the whole United States contain a timber capital little greater than will have to be maintained at all times, if they are to continue to yield as at the present time, which they are fully capable of doing if managed properly. Therefore it is time for sustained annual yield management now. Foresters, by surrendering almost completely to the lumberman's view of forest finance, based on considering the stand as a fixed quantity, to be cut now or in the future, are contributing to delay of the time when any real steps will be taken to rectify conditions. Meanwhile time is being wasted on such quack remedies as reform in forest taxation, etc.

3. *Only the forest organized for sustained annual yield has any safety against mismanagement, or at all times attracts that degree of attention which makes for continuous care.*

The forest bearing mostly mature timber is a standing invitation to overcutting. It is believed that already the Forest Service has been unable to withstand this temptation in many cases where high prices were offered. It can be surmised, then, that if at any time some political forester should be in charge of the Service—and this is not at all unthinkable, as other technical branches have suffered such a fate at no distant time in the past—he might take a notion to make a record in securing immediate income. The way to do it would be to sell these

large mature tracts, not at high prices as the Service has done, but at prices such that lumbermen would grab at them in a minute. There are a great number of tracts perfectly adapted to operations of this sort in western Washington and, without doubt, elsewhere.

If, instead of leaving these tracts open to such opportunities, they were at once organized for sustained annual yield, and cutting begun under contracts adapted to this purpose and providing for withholding sale of more timber until the existing contracts were completed, each area so treated would be relatively safe from mismanagement for years to come. Those tracts too inaccessible to treat in this way will be safe from overcutting, anyway. The longer each tract is under annual sustained yield the safer it becomes, because more and more it consists of young timber which cannot be cut immediately, and, at the worst, only temporary mismanagement is likely to result.

On the other hand, tracts all of young timber, yielding no income, are the first to be neglected for that reason, especially under inexpert management. The average lumberman of the present day, for example, would not spend a cent on such a tract. Can we be sure that we shall never have this viewpoint in control? Sustained annual yield management giving continuous annual profits from forestry on every unit of National Forest would attract attention and secure expenditures on every unit of forest. It would be the best possible object-lesson of the results of forestry, because the concrete illustration convinces where the abstract has no effect. Even the layman could get the principle with the object-lesson before him in the form of a tract bearing all-age classes, one of which comes to maturity each cutting period. With all young timber on one watershed, all old somewhere else, this periodicity of maturity would be no more obvious than it is today, when we have that precise condition, except for some preponderance of overmature.

Only when each producing unit of forest has been brought over to approximate sustained annual yield management will the management be relatively safe in the hands of the non-technical man, or the forester with the point of view of the miner or the lumberman of the old school.

The writer hopes that a substantial majority of foresters can agree on the foregoing points, in the main, for application some time. The parting of the ways comes when the question arises as to when we shall begin to work the forest on sustained annual yield. Shall we begin as soon as possible, or wait until some indefinite time in the future? This question will be treated under the next heading.

GRANTED THAT APPROXIMATE SUSTAINED ANNUAL YIELD IS THE BEST FORM OF FOREST ORGANIZATION, SHOULD EFFORT AT ONCE BE MADE TO WORK TOWARD THAT CONDITION?

Many foresters concede this form of organization as the best in *theory*, and proceed to disregard it in *practice*. The National Forest Manual, page 73-S, states formally: "On Forests which contain large quantities of mature stumpage in excess of local demands, no restriction upon the possible cut is necessary." The local demands mean from industries other than lumbering, since, as heretofore explained, the Forest Service does not yet recognize permanence in the lumber industry as of any importance, although, as shown elsewhere, this is the only industry in which permanence of the industry and the homes and institutions relying on it are absolutely dependent on permanence of the timber supply. To other industries, such as ranching, etc., about which the Service is concerned, the future of local timber supply merely means a little higher price for lumber or substitution of some other material, neither of which can affect the industry at all vitally.

In those cases where limitation of cut is considered desirable and is prescribed, it is recognized that this limitation may be inconvenient at any time, and regular procedure is provided for raising the limitation. In the language of the Manual (pages 6-S), "On other Forests, recommendations should be made to extend the limitation as necessary to cover desirable sales."

These quotations and their context show that Forest Service policy considers sustained annual yield management as of no immediate importance. If disregard of it at present takes the form of cutting, especially clear cutting, all merchantable material on large areas, such regulation of the yield will be impossible for 50 to 100 years. Therefore it is fair to conclude that the Service considers that the question will be of no moment on such areas for about that length of time.

Violation of annual sustained yield regulation may take two forms: (*a*) overcutting, (*b*) insufficient cutting. Both of these practices are followed and defended on National Forests, thereby deferring sustained annual yield management for varying periods of time. It is necessary to show, then, that neither practice has in most cases that justification necessary to warrant its use in violation of generally accepted principles of management. They will be taken up in order.

(*a*) *Overcutting.*—This may be justifiably practiced on forests remote from transportation where local needs demand, but these reasons for overcutting are so seldom the real ones as to be entirely negligible.

Practically the only active reason for overcutting is high prices for timber. Since the writer believes that this is a wholly inadequate reason for such action, he will rely on the arguments for sustained annual yield already advanced to show that this practice, clearly easy for the Service to prevent, is unwise. The arguments most dwelt on were: (1) Sustained annual yield gives the best social results. This is perhaps the most important factor in National Forest management. (2) Sustained annual yield, where large enough to permit erection of an efficient plant, gives the best financial results from the utilization of the present stand. Where sustained annual yield is not possible, the nearest approach to it which will permit erection of an efficient plant should be used. This argument neutralizes the price argument, with which overcutting as a practice is upheld. (3) Only forests organized under sustained annual yield are at all safe from mismanagement. Overcutting sooner or later will remove most sources of income, and will then cause the manager to lose interest in that particular tract. Result, exposure to fire and other dangers, which would be looked after on the income-bearing property.

(*b*) *Insufficient cutting.*—In former years the writer was wont to be accused of setting up a "man of straw" when he presumed to intimate that the Forest Service did not in all cases desire to cut timber wherever it was overmature and overcutting would not result. That accusation can no longer be made, because semi-official utterance now states the position of those who really believe immediate cutting on the National Forest is a necessary evil. Mr. W. B. Greeley,[5] after reviewing alleged conditions as to inaccessibility of forests, etc., has stated in reply to the writer's argument[6] for immediate cutting within sustained annual yield limits, that "from the standpoint of delaying the cutting of overripe timber and the full use of the productive capacity of forest land, this is bad. Viewed from another angle, it may not be a public misfortune. It is generally conceded that at the rate of consumption prevailing during the last decade another generation will witness the practical exhaustion of the virgin timber supply of the United States. It is reasonable to believe that a critical economic period as regards the production and use of lumber will attend this exhaustion. A large national timber reserve will be of inestimable value in tiding the country over such a period." Again, further on, he says: "In spite of the loss from deterioration, the country as a whole may be benefited more by reserving a considerable portion of these stands against the time of critical need than by cutting them

[5] W. B. Greeley. Proceedings of the Society of American Foresters, Vol. VII, No. 1, page 45.
[6] Burt P. Kirkland. Forestry Quarterly, Vol. IX, No. 3, p. 375.

off too rapidly under present market conditions in order to put the growing power of the soil to work."

This states clearly, though not in explicit terms, the fundamental fallacy which it must be concluded dominates Forest Service timber-sale policy. The fallacy, briefly stated, is: "Storing up mature timber now on the National Forests will increase the nation's total supply of mature timber in the future." The writer prays for strength to his arm to demolish this fallacy once for all among foresters, official or otherwise. It may be expected to persist among lumbermen of the old school, or among the mining fraternity, but certainly not in the ranks of foresters. The argument might legitimately be advanced that mature timber should be stored on the National Forests beyond the needs of sustained yield in order to help the stumpage owner to make good on his investment, or even to prevent overproduction in the industry; but certainly every forester owes it to the profession that he should spend enough time in careful thought along this and related lines to prevent him from speaking publicly of the producing forest as one would of a mineral resource.

The facts and unavoidable conclusions which are depended upon to explode this fallacy are as follows:

1. The logging camp and mill capacity in the United States are in all times, both good and bad, far greater than needed to supply market demands.

2. In every year, prosperous or otherwise, many mills are shut down part or all of the year, not because they cannot get plenty of raw material, but because they cannot operate and market their product at a profit, or even at cost.

3. Even price-cutting will not increase the market in any substantial degree.

4. Since these mills are marketing all the market will take at a profit (or even at a loss in many cases), there is all the timber cut that can be cut, so far as the nation as a whole is concerned. Conversely, no matter where the timber is cut, there will be just so much national reserve of mature timber.

5. Since there will be just so much reserve of mature timber for the nation as a whole, cutting on the National Forests merely takes the place in volume of so much cutting outside.

6. Fire protection on this standing timber outside the National Forests being just as good or better than inside—more money per acre is being spent outside on many areas—there will be just as much mature timber of the present stand left for use in the future if what we do cut is cut in the forests as there will be if it is cut outside.

The entire argument depends only on the question of whether the first three items are in accordance with fact. As to number one, every one in connection with the lumber industry can substantiate its truth. Although I am not now able to cite the place where it appeared in print, the president of the National Lumber Manufacturers' Association stated a few years ago, in a letter to President Taft, that the mill capacity in this country was at all times 50 to 100 per cent above what the market would take. As to the second point, every one who has lived in a lumber region knows it is true. The writer has been in the Pacific northwest, both in times of prosperity and of depression, and at no time were all mills and camps operating.

The truth of the third item has been demonstrated by the fact that though many mills have sold below cost of production, still the consumption has not increased. Thus it is evident that even if sale of National Forest timber was accompanied by price-cutting to the consumer, which would seldom, if ever, be the case, the total stock of standing timber in the United States would not be diminished by the increased cutting on the National Forests.

As to the conclusion embodied in the fifth item, it may be said to be true not only in theory, but in practice. The writer has dealt with a good many timber purchasers, but never negotiated a sale that he can remember except to experienced operators, who would have bought timber outside the National Forests, if not inside. Moreover, in nearly all cases the timber was logged by existing equipment, except the railroad construction, and sawed by existing mills.

It is not claimed that a showing that cutting on the National Forests will not diminish the total stock of timber in the United States more than it will be diminished by cutting outside them constitutes a complete argument for cutting on the Forests. It is, however, such an important step in reaching a conclusion concerning the advisability of immediate cutting that it would be worth devoting an entire article to if it did not seem certain that a single statement of the facts would accomplish the same purpose. It will be assumed, therefore, that this persistent fallacy is disposed of.

We can now pass on to the question of whether it is most desirable to have our reserve of standing timber on or off the National Forests, and our cut-over lands the reverse of whichever of the above conditions is chosen. The writer believes that from the general public standpoint, though perhaps not from the standpoint of timber speculators, it is best to have the standing timber left on the private lands and the cut-over lands on the National Forests within limits of sustained yield from the latter. The reasons follow:

1. The standing timber will be equally well cared for on the private lands; hence preserved for future public use just as effectively.

2. It will continue, if on private lands, to furnish large public revenues to the county and State (almost the only source of revenue in some western Washington counties) until cut, after which the abandoned lands yield very small revenue.

3. If, instead of leaving the timber standing outside the forests, it is cut, the cut-over lands remaining receive no care as to securing reproduction, and if it comes in accidentally it will not receive protection from fire. Fires in young growth are still considered by lumbermen not to constitute any damage; hence they spend nothing in protecting it except as such expenditures are incidental to protecting the old timber.

4. Three being true, it follows that the lands cut over outside the National Forest will yield almost no timber; and since they are not yet needed for agriculture (in the West) they produce nothing, not even the price increment which storing timber upon them might have yielded. Part of this price increment would have gone to the public in taxes.

5. If timber is cut on the Forests it yields immediate revenue to State, county, and nation, this being added to the revenue the first two receive from the private timber outside as a result of leaving it standing.

6. Since cutting on the National Forests would properly be only in mature stands, either stagnating or decreasing in volume, and would be immediately followed by reforestation and growth of new timber, it would result in a positive addition to the future timber supply which can be secured in no other way. *That is, it is absolutely clear that diverting cutting from private lands, where lands lie waste after cutting, to National Forests, where reforestation follows, must result in a clear gain of volume production equal to the amount produced on National Forests following cutting.*

To summarize both lines of argument: Cutting on the National Forests will merely take the place of cutting elsewhere; hence leaves just as much mature timber standing as would be the case if cutting is withheld from the Forests. Furthermore, cutting on the Forests is followed by reforestation, thus insuring a certain increase in the future timber supply by reason of diverting the cut to National Forest lands. There are other important advantages, such as the certainty that the longer the timber remains on private lands the better the chance that reforestation might be taken up by the private owner, the State, or the nation, at the only time it can be done cheaply—that is, right after the standing timber is removed. It can further be shown, without difficulty, that if we concede sustained annual yield as the type of management to be entered upon

when cutting does begin on the Forests, every year's delay leads to the permanent loss of the amount that might have been taken in that year.

Space does not permit going into these other considerations, but those discussed are believed sufficient to prove the case from the standpoint of benefit to the general public.

In order to make the case clearer, however, it is desired to sketch the logical results of Forest Service sale policy in these respects in a single region—the Puget Sound region. Unlike most localities west of the Cascades, in Washington and Oregon, cutting is in this region well advanced on account of the early development of the industry here. The total timber on the National Forests tributary to the Sound is in the neighborhood of 30 billion feet board measure, practically all mature or overmature. The timber in private ownership is in the neighborhood of 60 to 70 billion. Familiarity with many of the larger holdings discloses the fact that with two or three possible exceptions none of the private holdings are expected to last their owners more than twenty years. The company that has a twenty years' cut ahead is, in fact, considered very exceptional. It may be concluded, then, that timber in the hands of mill owners will not last more than twenty years. Timber in the hands of stumpage investors may be expected to add to the life of the private timber supply five or ten years.

The National Forests and points of them tributary to the region are capable of yielding, under annual sustained yield management, in the neighborhood of 500 million feet board measure annually. They are now yielding only 20 to 40 million feet, practically all of which has lately undoubtedly been cut at a loss to the purchaser. If divided into proper units of regulation, there would be ten or twelve of these. Practically every one of these units is near enough to transportation at some point to permit sales, if they are priced at true value and freed of unnecessary restrictions. Railroads run through some units, and scarcely any present conditions require greater expenditures for construction of transportation facilities than are incurred by dozens of logging concerns in opening up private timber.

Now let us see what the logical result of this policy will be if continued in this region. Since all of the cutting is kept on private lands, which lie waste for the most part after cutting, being neither reforested nor used for agriculture, there is annual decrease in the taxable timber. Five hundred million of this which might be cut from the Forests represents unnecessary decrease of the private timber. Since taxes average about 1¼ cents per thousand per annum, the tax revenues are annually decreased by this policy by some $6,000—not important, perhaps, in any one

year, but, being cumulative, it will amount in 10 years to $60,000, in 20 years to $120,000 annual decrease. A policy of cutting to the sustained annual yield limit of the Forests would save this annual revenue from taxes on private timber, and since the Forest timber could be easily sold at an average of $1 per thousand or more, 25 per cent of which would go to the counties within the region, the National Forest revenue would add $125,000 annually to local revenues, besides adding certainly $250,000 annually to the Federal revenues above all costs of Forest administration. These revenues are sorely needed locally to meet expenses of roads and schools in a pioneering community, where tax rates are 30 to 40 mills per dollar of assessed valuation. Placing the National Forests on even a self-supporting basis can be depended upon to "make such a hit" with Congress as to make additional appropriations of a million or more a year easily secured. So much for effects on immediate revenue. Increasing stumpage prices will rapidly increase this revenue, both from taxation of private timber and from sales of National Forest stumpage. Doubling the revenue in 10 years and quadrupling in 20 years would be modest estimates of the possible increases. This great difference in local and national revenues under the two systems is an important point in favor of beginning cutting now.

It is not the most important, however. The policy of cutting according to an annual sustained yield basis would in 20 to 30 years demonstrate the success of forest production as a business proposition—in other words, the success of forestry. The policy of holding will demonstrate nothing that some of our great timber companies will not demonstrate equally well, except that we have no large timber owners, with the possible exception of two railroad companies, who are cutting so small a proportion of their standing timber. Twenty years of successful forestry as an object-lesson on a large scale by the only owner that can at present carry it on will do more for the cause of forestry than 50 years of argument for forest practice. With this example before those owners who still have timber left by reason of cutting on National Forests, instead of their own land, and with the revenue showings which forestry in this region can make when starting with mature timber, will do more to make them inquire into forestry for their own lands before it is too late than anything else. If they find it an uneconomic proposition for the private owner, there is a fair probability that they will advocate transfer of the lands to the State or Federal government. The latter is undoubtedly the most economic form of ownership, provided it proves capable of managing land for forest production.

Let us next examine the question from the standpoint of volume production. Under present policy, neither the National Forests nor private lands produce any volume to speak of, because the stands are prevailingly so far overmature. The total stand of mature timber is being decreased by some two billion feet board measure per annum, and nothing is growing to replace it. Fifty years may therefore be expected to exhaust every stick of it at the present rate of cutting. Under existing Service policy the private timber will go first, and the lands be laid waste, as have been thousands of acres already. Then, according to Mr. Greeley, the Forest Service will throw in its timber to meet this "time of serious need."[7] It must be particularly noted here, however, that it will be able to do little more toward meeting this need then, if it takes up a sustained annual yield policy at that time, than it would be if such a policy had been started today and pursued for 30 years. Sustained annual yield starting now, or 30 years hence, can take only some 500 million per annum from the National Forests when it does start. If we wait 30 years in starting, we have lost 15 billion feet of forest production forever, unless we overcut. So, after all, we cannot start sustained annual yield and Greeley's policy together. If we cannot get sustained annual yield established before that time, presumably Greeley's policy will be the accepted one and the cutting will be entirely transferred to the National Forests. Two billion feet a year will be cut, and of course followed by reforestation. It will take at this rate 15 years to clear up the mature timber on the Forests. What will be left in the region? Simply what parts of older lumber regions can show today, with the exception that the National Forests can show a large area of young stands, none of which, except those now establishing and to be established on burned areas, will be more than 10 years old, or ready to yield another cut, aside from thinnings, inside 50 to 60 years. Private lands will be waste except for a few farm woodlots and chance areas of young growth which have escaped fire. So, while the next 50 years are well looked after, the subsequent years will be lean indeed. Perhaps these are too far away to concern us. There are foresters who think otherwise of national aims.

The foregoing predictions are logical results of present Service policy. The actual results would, of course, not involve such sharp transitions from cutting one kind of timber to another, nor such a sharp ending. With these slight modifications, the foregoing furnish a true picture. To recapitulate briefly, the main logical results of present policies mean unnecessarily small public revenues at present and the total loss of some

[7] W. B. Greeley. "National Forest Sales on Pacific Coast." Proceedings of the Society of American Foresters, Vol. VII, No. 1.

15 billion feet of timber, unless cutting proceeds later with total disregard to annual sustained yield. All the growth which might be secured on the 10,000 acres or more which could be annually cut over for the next 30 years will be lost any way. If annual sustained yield is disregarded in order to relieve the "period of stress" from 30 years on, total exhaustion of the forest will follow at a time when the young growth following cuttings 30 years hence on the National Forests is not of an age to furnish any yield for 50 years thereafter.

Compare the foregoing logical results with those that can be secured by adopting sustained annual yield on the National Forest within this region.

The past 5 years would have been sufficient to bring nearly every one of these 10 or 12 units up to their sustained annual yield limits. Since a policy was maintained during this time which held the forests out of use, it will take in all probability the ensuing 5 or even more years to bring this about. Industrial conditions are now less propitious than 5 years ago, but, on the other hand, there is more available knowledge of the forests with which to work. The end of this period would see the Forests yielding about 500,000,000 feet board measure per annum, which would go to decrease the cutting on private lands. Private owners could afford to hold some of their timber, because of the revenue received from National Forest timber cut in their camps and mills. This would, at least, make a certain amount of the private land function for a few years in storing timber, while releasing annually about 10,000 acres of National Forest land for growing timber—both clear gains. Thirty years of such cutting would contribute 15 billion feet of National Forest timber to the market and prolong the cut of private timber for 7½ years. The remaining 15 billion of the 30 billion total on the Forests could be used to prolong the cut in the region at the regular rate for approximately another 7½ years. This would leave the forest in what condition? The old timber would be gone in the same length of time as under present Service policy, but there would be 10,000 acres of stands coming to the age of 45 years annually, so that the region would at least have timber for local needs. A better policy would, of course, be to keep the forest on sustained annual yield continually, and not overcut when the private timber comes to an end. Under this policy the National Forests would supply 500 millions annually, at all times in the future, plus the thinnings, which would be heavy by the time the private timber would be exhausted. In practice, the private timber would be exhausted gradually, and, there is reason to hope, be supplemented by some practice of forestry on other than present National Forest lands. If sustained annual yield

management were adopted now, there would be only a gradual transition from the cut in virgin timber as privately owned timber becomes exhausted, over to stands produced under management.

The writer would close this section of the discussion with the plea that the Forest Service start the practice of forestry in at least one limited National Forest region; that it should practice not just silviculture, not just protection, but forestry, including utilization and proper forest organization. If it should select the Puget Sound region for this first American experiment on a fair-sized scale, he will pledge his personal efforts to explain just what it means to lumbermen and to the public in general. From previous experience, he feels sure this would not be difficult to explain, or to obtain coöperation of lumbermen and public. He knows other foresters who can be enlisted in the work, which is all important to the profession and to the public at large.

It may be said, further, that while employed by the Forest Service he had as fair success in making as many timber sales in the Puget Sound regions as any one up to 1912, when he left the Service. It may therefore be of some interest to record that in his experience the strongest selling argument with most lumbermen was the statement that cuttings could be guaranteed for years to come on the area in question. In other words, proper forest management is good business management, both for the forest owner and the purchaser of stumpage. It is, furthermore, not a difficult matter to explain the essential principles of forest management to the business man and get his coöperation in carrying them out. It is, in fact, a thing of far greater difficulty to explain to the business man or the public why the Forest Service will permit a large watershed to be denuded of timber in a short space of time. Such practice squares no better with the popular conception of forestry than it does with principles of forest organization.

OTHER ARGUMENTS BEARING ON IMMEDIATE CUTTING

So far, cutting policy has been considered mainly from the standpoint of the general public as owner and consumer of wood material, and of that section of the employing and laboring classes engaged in exploiting National Forest timber. Whatever success he has had in advancing this view in the foregoing pages, the writer will never concede anything but sustained annual yield management, or the nearest approach to it, as contributing to the best interests of these classes. There remain to be considered two other main interests, to which space permits only brief consideration, although perhaps entitled to more.

(*a*) The interests of the lumber manufacturer.

These will be well served in this region by sustained annual yield policy, because it tends to give him a permanent supply of timber for his plant, in which he has heavy investment. This would apply even more strongly to the pulp and paper manufacturer. Sustained annual yield policy beginning now may also tend to keep stumpage prices lower, so that the manufacturer here will be in a somewhat more advantageous position than his competitor away from the National Forests. That is as it should be. Certainly, if National Forests serve their purpose as claimed, they will keep wood products somewhat cheaper by helping maintain adequate supply. That lumber prices will be cheapened at present cannot be expected, nor is it desirable, at least so far as selling prices at the mill are concerned. That an immediate sustained yield policy would have any appreciable effect in the way of overproduction or price-cutting can be denied absolutely. The competitive system will attend to that for years to come without any help from National Forest timber. Competition has already cut prices as low as will permit operation of mills. Furthermore, the supply of lumber marketed will not be increased, because the present manufacturers will cut the National Forest timber in place of rushing off their own or buying other timber in private ownership. So the manufacturer in the National Forest region will be pleased at a change in policy unless his interests as a stumpage owner are paramount to his interests as a manufacturer.

(*b*) The interest of the stumpage owner.

Here is the only interest which conflicts in any vital way with the inauguration of immediate annual sustained yield on National Forests. Whether he has a legitimate "kick" can be judged from the following facts: The Federal government granted to the present stumpage owners or their predecessors practically all the timber they have, either free or at a nominal charge, seldom over $2.50 per acre. Four-fifths of the timber having been alienated in this way, is it unreasonable if Uncle Sam does with the other one-fifth as is being done with the four-fifths in private ownership, viz., make as good a thing as he can out of it for himself? Uncle Sam did even better by the private owner of the four-fifths after disposing of most of the four-fifths cheaply. He withdrew some 600 billion feet of timber on the National Forests from gift or sale at cheap price, and thereby boosted the value by from $1 to $2 per thousand feet within a very short space of time. Can the private owner, then, find fault with very good grace if Uncle Sam should decide to put from 6 to 10 billion feet of this back on the market each year?

The writer is not without sympathy, however, for the innocent investor who, ignorant of or disregarding the laws of compound interest, put his money into timber lands with little possibility of making good on his investment. He does not believe, however, in mismanaging the National Forests in order to help out this investor, whether big or little. A better solution would be for the Federal government to buy back this timber from those investors who are tired of it and place it in the National Forests, where it belongs, as soon as the ability of the Federal government to practice all the branches of forestry on it is demonstrated. However, it is important to demonstrate before this is done that the price policy will not be that of a lumber trust having monopolistic power.

It would be trespassing on the good nature of the editor to extend this discussion to much greater length; but it is desired, in addition to the foregoing arguments, to comment specifically on some of Greeley's arguments in the article already cited. First, the matter of accessibility. The writer has never advocated cutting where it was impossible. However, the matter of accessibility is far less troublesome to sustained annual yield management than it sounds. Sustained annual yield management at its inception generally only necessitates that one edge or one corner of a unit of regulation be accessible. This is already true of the majority of the suitable management units of National Forests, provided exorbitant stumpage prices as a bar to management are removed. Inaccessibility is more troublesome where it is desired to cut over large tracts at once, with the sole aim of securing high stumpage prices. Granting, however, that there are entirely inaccessible units, it would seem that instead of this being an argument against annual sustained yield on the others, of which there are an abundance, it would be an argument for bringing the cut on the latter up to sustained annual yield limits as soon as possible. It is doubtful whether there is a single one of the ten or twelve units in the Puget Sound region on which cutting up to sustained annual yield limits is not almost immediately possible whenever the Service will sell at present values rather than holding at speculative ones. Of the other National Forest units, probably 50 per cent is accessible at present values.

Regarding sustained market, it may be said that it will take no very high skill in salesmanship to place six billion of National Forest timber on a national market which uses 45 billion, providing, again, it is offered at present values.

As to stable values: In advocating sustained annual yield only an approximation to this is expected by any forester. No one wants to cut an arbitrary amount each year. The market has to have timber in times of

depression as well as prosperity, however, and there is no reason why the National Forests should not furnish their quota. If the Forest Service can work out contracts extending over twenty years, there ought to be no difficulty in handling periods of prosperity and depression. Of course, under present price policies, the Service will make sales for the most part only on the peak of prosperity, and each following period of depression will have its train of business failures among purchasers of National Forest timber, such as those occurring in the present period. Some elasticity in the price policy would avoid these failures, keep labor and capital employed, and thus help to shorten periods of depression. There has been much regretting in the selection forest regions because lighter cuttings cannot be made. With stumpage prices of $2 to $4 per thousand, how can this be expected? The first obvious silvicultural measure in such regions is to go over all the area possible, making a light cutting to save the defective and overmature trees and give those remaining better chances for growth.

Without such an immediate cutting enormous quantities of material will be lost forever. To avoid this, the Service would be justified in putting down stumpage prices very nearly to the cost of administration in those places. This would be done if one of the objects of management was to secure the greatest present and future yields possible from the forests. From the actual practice one would infer that the main object of management as to the timber is to be able to state in each annual report that the average stumpage price obtained for the past year was higher than ever before—this with disregard to whether the best financial results are secured from the Forests as a whole. High stumpage prices do not necessarily accompany the best financial results. It is possible by forcing high prices to decrease the volume of sales, so that sales not only give small total returns, but the material that goes to waste because it cannot be cut at the high prices constitutes far greater loss of revenue than would lower prices. There is little doubt that this is the exact situation on the National Forests.

Greeley's statement[8] that the boundaries of administrative units do not yet coincide with the limits of economic units which should form the units of regulation is quite true. But instead of the economic units being larger than administrative, as he suggests, they are usually smaller. The proper economic unit by which to regulate annual cut is the producing unit—that is, the unit on which the timber is grown, logged, and usually manufactured, as far as rough lumber at least. This is no doubt the same as meant by Moore by the term market unit. Since the market

[8] See article cited previously.

where the timber is consumed may be next door or a thousand or more miles away, the term market unit is subject to various interpretations. In the case of the Whitman and adjacent Forests, Greeley has interpreted it as determined by the route over which the timber moves to market, namely, the Oregon Short Line Railroad, which carries the timber to the consumer along its lines. Apply the same interpretation to all the Forests of western Washington and they go in one market unit also, viz., the Northern Mississippi Valley, because the timber from them moves out over the northern transcontinental lines to that market chiefly. By the reasoning applied to the Whitman group, they may be properly regulated as one unit; but why stop at the Forests of half a State; why not regulate by a district or the United States? In making this statement the writer is not trying to be facetious; for, as a matter of fact, regulation for the entire National Forest area will secure all the results that regulation by the large group, including the Whitman, will secure. The only result that regulation, either by the whole National Forest area or large groups, would be equality of volume production and some regularity of income as to the large area. It will not secure permanent mills and logging operations, but merely continue the same type of lumbering operations we have had in American practice in the past. It will neither secure the desirable social results heretofore described nor the careful attention to each producing unit necessary to good silviculture and utilization. In short, it is not regulation at all, and to call it such is merely to apply salve to an uneasy conscience. Precisely the same results will be secured by forgetting all about regulation and cutting where the best price offers.

As to the statements concerning the Butte Mining District group, they again convict the Service of proceeding according to one chief object of management, viz., high stumpage prices on what little is sold. The writer is not familiar with this area; but on the face of the situation Greeley's plan of regulating by a group of three Forests means that though it is in the power of the Service to regulate by producing units small enough to keep the industry permanent in each, with permanent woods population and close utilization due to having permanent transportation, the Service has chosen the big sale and high stumpage prices with periodic cut. Smaller cutting areas would undoubtedly give greater volume production due to better utilization of thinnings, windfall, and fire-killed timber, with perhaps lower average prices for the timber cut, but a practical certainty of a greater net return from the whole area. Since this large scale so-called regulation makes little change in lumbering methods, contributes almost nothing to silvicultural care of the Forests except at the

time of cutting, nor gives any other result generally expected from regulation, the writer believes frankly it should be abandoned. Instead it would be as well to cut mature timber wherever it is found and in such quantities as needed by the mines. When there is no more mature timber for the time being, let the consumer go elsewhere. In other words, regulation should properly be chiefly for the producer, including the capital and the labor employed. If for the consumer, clearly it is not needed, for he will be his own regulator. He will use timber when he needs it and leave it in the woods when he doesn't. When the immediate supply is exhausted, he will go to a greater distance. This may be the most economic way for him, and if he alone is to be considered, regulation beyond that imposed by his requirements is foolish, the only care necessary being to see that every area cut over is reforested as quickly as possible.

Furthermore, the writer wishes to add that he has no sympathy with the idea that because it will cost money to grow timber in the future we should let our present mature stand—the free gift of nature—rot in the woods rather than sell at low prices. He believes it will be time enough to charge consumers the cost of growing timber under management when they begin to use that timber. These prices will come long before any timber has come to maturity under management. The consumer has as good a right to the present stand at what it cost to grow—viz., nothing except recent cost of protection—as has anybody else.

CONCLUSION

As President Wilson has said, in substance, each piece of truth fits every other piece and the whole makes a harmonious fabric. So examine annual sustained yield management from all standpoints and it meets every test as being the best form, both today and for the long run. Its social results are unquestionably the best; it makes possible the greatest yield from thinnings; the salvaging of insect, fire-killed, and windfall timber, thus providing the greatest volume from the Forest and contributing to this extent toward the greatest financial results. It eliminates depreciation of logging and mill equipment due to exhaustion of raw material, one of the chief sources of depreciation in the past. It changes the whole conception of the lumber industry from the present one, which is that temporary construction of mills and camps situated in shacktowns is a necessity, to the idea that with a permanent supply of raw material, permanent logging railroads, and mill plants situated in permanent towns, with permanent residences, business buildings, schools, and churches, is the normal state of affairs.

So, also, protection against fire and insects is most easily secured and the maintenance of the most efficient administration is made possible. In short, approximate sustained annual yield management contributes in the highest degree to the welfare of the Forest and the industrial community dependent on it, while at the same time meeting the needs of the consumer usually as well—often better—than any other type of management.

Having concluded that the nearest possible sustained annual yield management is the best, not only for the future but also today, the way is now clear for discussion of the methods to be used in the preparation of such plans. The writer has already taken too much space to enter here upon this discussion. American Forest literature is reasonably well supplied with information on this phase of the subject. The profession is especially to be congratulated on the acquisition during the past year of such a practical and common-sense treatise on the subject as has been provided by Prof. Filibert Roth, of the University of Michigan.[9] Mr. J. C. Kircher also makes valuable suggestions in the Forestry Quarterly.[10] The writer, of course, does not agree with Mr. Kircher that approximately sustained annual yield is not now to be entered upon. It is also doubtful whether the classification of "preliminary" and "final" plans is desirable. The classification should rather be "general plans" and "detailed plans." There can, in the nature of the case, be no "final" plans for years to come, if ever.

The data of plans should be presented almost entirely on maps, with tabular summaries at the bottom. This applies to data covering stand of timber, soils (character and quality for Forest growth), planting data, and everything else needed. A few general summary tables should be added. Silvical data can also be presented on the maps, so as to be intelligible to the forester familiar with the region in question, on whom should rest the entire management of the Forest except for the broad, general principles. A few type-written pages should present all the written prescriptions necessary in the plan, which should include the regulation of the cut, but not detailed distribution, to certain compartments. The prescription in this respect should rather be merely to take up cutting by classes of Forest based on age or condition, cutting first, of course, those silviculturally most in need of cutting.

There will be cases where sustained annual yeld by small units is not possible. Here we should at least limit cut to the annual cut necessary to supply an economic plant. If we cannot have sustained yield, then

[9] Filibert Roth. "Forest Regulation," Ann Arbor, March, 1914.
[10] J. C. Kircher. Forestry Quarterly, Vol. XII, p. 145.

have yield for 25 to 50 years. Use of thinnings and closer utilization by that time may make continuous operation possible.

The writer hopes that this symposium will lead to such clarification of thought toward sustained annual yield management that the Forest Service will be heard as enthusiastically advocating production of timber in the future as it has been storage of the present stands in the past. The writer wishes to reiterate his lasting belief in the economic and social need for continuing the National Forest system, and regrets that his own experience impels him to differ radically with Service policy in handling National Forest timber.

REGIONAL FOREST PLANS

BY PROFESSOR D. T. MASON

University of California

The Forest Service has proposed to make working plans for each of the National Forests. The outline prepared for making these plans, issued in 1912, indicates that the plan will include a large amount of description of general conditions existing on the Forest, statements of general principles for handling various lines of work, etc., most of which is as applicable to many other Forests in the region throughout which the same general conditions exist as to the particular Forest for which the plan is being made. There are more minor differences between various parts of an individual Forest than there are major differences between the various individual Forests of what may be called a forest region. By forest region is meant a territory, usually including a considerable number of National Forests, in which the climatic, topographic, soil, and other conditions are sufficiently uniform to give fairly uniform forest conditions throughout the region when elevation, aspect, etc., are approximately the same. The preparation of plans, as required by the standard outline, for individual Forests within a given forest region, would result in a large amount of duplication, since each would describe in considerable detail a great number of things which are uniform for all of the Forests in the region. For example, taking the working plan outline, there are named below a number of the points which are of regional rather than merely of local National Forest importance:

Description of Climate:[1]

Forest Types—

Composition, occurrence, distribution, age classes, condition of timber, description, silvicultural requirements, principles, basis of system, etc.

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[1] Formerly in Forest Settlement reports a description of the climate for each individual area reported was required. This was found to result in repeating over and over again, hundreds of times in some cases, a description of the climate of a certain locality, as the Swan River Valley, in northwestern Montana. Such repetition is burdensome and useless, since in the scope of such a report the climate is never thoroughly described, and sufficient information is not given to permit those reviewing the report to learn what they wish to know, if they have any considerable curiosity as to climatic conditions in the Swan Valley.

- Species—
  - Climatic, soil, moisture, and light requirements.
  - Growth, form, volume, etc.
  - Reproduction.
  - Wood—properties, comparative values, etc.
  - Causes of injury—fire, insects, fungi, etc.
- Increment—Yield tables, effect of thinnings, etc.
- Timber Operations—
  - General markets.
  - Methods of utilization.
  - Costs.
- Objects of Management—
  - Watershed protection, species, classes of material, sustained or periodic yield, etc.
- Silvicultural systems and application for each type.
- Regulation of Yield—
  - Rotation—Cutting cycles, etc.
- Sales—Policy.
- Free Use—Policy.
- Forestation—
  - General relation to timber management.
  - Methods, species, etc.

Grazing:

Range Management:

- Types (description of each).
  - Important forage plants named.
  - Data on seasons of growth.
  - Forage value.
  - Carrying capacity.
  - Relation to silviculture.
  - Silvicultural and watershed protection.
  - Seasons.
  - Methods of handling stock—
    - Cattle—Salting to secure distribution.
    - Sheep—
      - Size of bands.
      - Herding method.
      - Salting.

Lands:

- Settlement policy.

Protection:

Fire:

Liability—

Expectation value of young growth, forage.

Value of watershed protection.

Hazard or Risk—

By types, danger of fires starting, difficulty and cost of suppression.

Protection required—Principles.

Insects:

Control, administrative measures, methods, costs.

Game:

Policy.

It will be noted that the points mentioned above, which are considered of regional rather than purely local importance, are not confined to silvicultural matters, but relate to grazing, protection, and lands as well.

The present plan of procedure is considered cumbersome and impracticable for the following reasons:

1. To develop individual Forest plans in accordance with the outline involves an immense amount of useless duplication, even if thoroughly qualified men on the Forest have time to do the work.

2. It would be done in many cases by men poorly equipped for the work.[2]

3. Through lack of judgment on the part of many of the men assigned to such work, through their lack of broad experience, and because of their seeing things through local eyes, policies, principles, systems, etc., are likely to be improperly developed.

There is a considerable amount of information, important to all supervisors in a forest region in managing their Forests, which is available to only a few supervisors. It can be made generally useful better through the preparation of regional plans than by following the present scheme.

The Forest Service has now a well developed and rather thoroughly crystallized general service policy applying throughout the districts. It has a somewhat less well defined and less completely crystallized district policy in each of the districts, of course better developed in some than in

[2] There are many instances known where the forest supervisor has little interest in doing the work and less understanding of how much is involved. In one case a supervisor said to his forest assistant on Wednesday afternoon: "Now, let me see; you have finished up that marking work on the Smith timber sale and those June 11 reports, so I think you had better spend the rest of the week making that forest working plan that we have got to turn in. You had better start right away on it and get it done by Saturday night."

others. The district policy is not nearly so definitely outlined as is the general Service policy, as a rule, because in most districts, certainly, the policy has never been thoroughly pulled together and coördinated, although the different features of it may have been, and usually are, quite thoroughly worked out. Much information of district-wide importance, statements of policy, etc., are scattered through the open and closed files, remembered by the experienced men, but lost to those not long familiar with any particular part of the work.

Each of the National Forest districts can be divided into two or more fairly easily defined forest regions. For these regions a more or less uniform policy has been developed, consciously or unconsciously, but it is usually looser and more poorly crystallized even than the district policy. For the individual Forest it is proposed to develop working plans without first developing definitely the district and regional plans. The district policy must necessarily conform with the general Service policy; the regional policy must conform with the Service and district policy, and the Forest policy must conform not only with the Service policy, as required in the outline for Forest working plans, but also with the district policy and the regional policy. Since this is true, it is not practicable for a supervisor to develop a working plan for his Forest intelligently and with the least waste of time and energy, unless not only the general Service policy, but also the district policy and the regional policy, have first been developed definitely and put in his hands. When this has been done, it will be found that most of the work which the supervisor would do if he proceeded in accordance with the present working plan outline would have been previously done for him, and would require no further attention on his part, excepting in the way of checking, criticising, noting exceptions, etc. His work would then be mainly to secure data with regard to his own local markets, inventory the resources of his own Forest, plan what to do with those resources, and arrange for the necessary improvements and organization to handle such resources in accordance with his plan. This in itself is a considerable task, without adding unnecessary burdens. Of course, in making the Forest plan, the supervisor will have to discuss, so far as necessary, the application of various parts of the regional plan to conditions on his own Forest.

In District 1, for instance, the following regions should probably be recognized: White-pine region, larch-fir region, lodgepole region; District 2 would probably wish to recognize a lodgepole region, a spruce region, and yellow-pine region; District 4, lodgepole, spruce, and yellow-pine regions; District 6, fir and yellow-pine regions. Of course, these suggested regions are named only for the sake of example, since the writer

is not sufficiently familiar with districts other than District 1 to attempt to name their forest regions. These regions should be large and broad. Each will ordinarily embrace a number of forest types. The region may well be named after the principal forest type.

A regional plan should be prepared for each region, following approximately the outline for Forest working plans, but eliminating the headings, covering those things exclusively of local National Forest imporance, such as inventories of various resources, etc. The regional plan would also include special manuals for estimating, fire protection, etc., applicable to the particular region as differentiated from other regions.

There is now available, in various forms and various places, a great amount of data for district and regional plans. The district plan can usually be got together without field work, merely drawing together and properly arranging the data already available in the various district offices. The district plan should not be voluminous, for most of the material will properly fit into the regional plans.

A considerable amount of field work will generally be required in the preparation of the regional plan. The best man available should be assigned to the work, preferably a supervisor of long experience in the region and possessing knowledge of a number of other Forests in addition to his own. Such a man should be responsible for the general preparation of the regional plan, but should be assisted by experts, available in various lines, handling technical details with which they were more familiar. When a forest region overlaps National Forest district boundaries, there should, of course, be interdistrict coöperation in the preparation of the regional plan.

After regional plans have been prepared, local forest officers should check them up carefully to make sure that they state general conditions correctly, note exceptions for their Forests, and offer criticisms and suggestions for betterments.

WORKING PLANS

BY PROFESSOR H. H. CHAPMAN

Yale University

No large business enterprise can be managed successfully without system. The larger and more complicated the undertaking, the greater the need of systematic conduct extending to all details of the business. But in elaborating such systems the danger at once arises of complicating the machinery unnecessarily. Red tape is not confined to Government bureaus. It sometimes reaches abnormal development there merely through lack of mobility and absence of pressure for economic results. The husk is retained after the motive or need has ceased to exist.

Underlying all enterprises are the specific objects striven for, which shape the entire policy. Technical methods are the means of attainment, but to avoid waste of time, money, and energy, the coördinating forces of hindsight and foresight are enlisted, the former by means of systematic records, the latter in the form of plans.

A form of record, or a plan which will result in a saving or achievement whose net value is greater than the cost of preparing the record or plan, obviously adds to efficiency or brings in greater returns per dollar spent. If a property or business can be managed as profitably without such plans or records, the expense of their preparation is a net loss, reducing efficiency. Plans which fill an actual need will be actually used. Those which do not will be discarded. A business is a vital, growing organism, and the living forces of brain and skill which are being expended upon it will seize upon and use those aids which cause a saving and increase the "output." The useless lumber will be stowed in the garret unless its employment is insisted on by those directing the work through errors in judgment. The trend of working plans should be towards eliminating and simplifying red-tape statistics and reports through experience, until only those records and plans are required which are vitally necessary in achieving the purposes of the business.

Differences of opinion as to the objects to be attained and their relative importance find expression in discussions over policy, sometimes leading to important reversals of said policy which alter the entire scope of the more detailed plans of management. Policy is the foundation, and must be firmly established. Those in supreme authority bear the responsibility for these foundation policies, which, in the case of National Forests, are

the interpretation of national legislation. But these laws allow great latitude in judgment as to methods of management and relative importance of different specific objects or uses of national property. Different grades of officials, from district foresters to forest guards, will tend to view the entire policy in the light of their own local conditions and problems, and to interpret or criticize the whole from their judgment of a part, thus falling into error. On the other hand, the central officers whose duty it is to coördinate the entire machinery must have a sufficiently comprehensive knowledge of all the various cogs and gearing so that their plans will work smoothly without too much friction in the bearings and waste motion.

As experience adds to the volume of knowledge, and as this hindsight is perfected by careful records designed to bring out the facts needed for future guidance, orderly and confident procedure will be substituted for more or less haphazard and well-meant experiments. Knowledge now existing merely as opinion in the minds of a few progressive thinkers eventually becomes the generally accepted basis of operations.

What is a working plan for a forest area? The term as used is made to include both the past and the future—the hindsight and foresight; the records, data, experience, and the actual plan of work or directions for future operations. This comprehensive meaning is permissible, provided a sharp line is drawn separating the past elements or summary of facts from the future elements or true "working" plan.

A working plan, as a whole, covers all the activities of a forest, and must be separated into as many chapters or subplans as will be useful in administering its provisions. Each of these subplans rests directly upon the data affecting the subject in question. The proper arrangement of a general plan would, therefore, consist of data classified by subjects and filed in connection with that portion of the plan to which it applied, with certain general data that will not bear subdivision and a general or comprehensive plan of administration dealing with the personnel and total resources of the forest. In this respect the outline adopted by the Forest Service seems to be acceptable, separating the plan, as it does, into the subheads of silviculture, forestation, grazing, lands, inspection, improvements, and administration. Any arrangement of a plan which proves to be the most useful and efficient is the one to adopt. There need be no theoretical limitations to such modifications.

The Forest Service, being the best example of the business of forestry, offers not only the most advanced development of working plans, but furnishes the best field for study and criticism of such plans. There has been a tendency to assume that working plans for National Forests were

non-existent except in a few cases. This error arises from two sources. In the first place, each Forest is in reality merely a part of the total area of National Forests which is being managed under a single colossal working plan. In the second place, the idea of a working plan has often been confined in its application to the single subplan dealing with silviculture, and to that portion of this subplan which takes up the question of regulation of the yield of timber. This narrowing of the definition of the term and its application is inadvisable. It can easily be seen that all National Forests are now being managed under some kind of working plans, and the question of enlarging the scope of these plans, requiring certain additional or different records, and shifting the emphasis on to objects formerly subordinated must be one of judgment and expediency.

The most fundamental consideration in national forestry is land classification. This fact has now received full recognition, and the former haphazard method of examination and listing of individual applications, necessitated by lack of funds and conducted often by rangers or inexperienced forest assistants, has given way to the system which includes cooperation with soil experts of the Department of Agriculture. As a general rule, a forester as such is not competent to permanently classify land as agricultural or non-agricultural. He can qualify as a land examiner by means of special training and through a knowledge of agriculture and soils.

The greatest danger confronting the Service in land classification is that arising from popular clamor for the opening up of lands for settlement. Where such outcry is raised a rigid investigation of the quality of the soil should be made by competent experts, and if this soil proves to be non-agricultural, it is the duty of the Government to resist or ignore all further efforts to secure eliminations. In most instances this hue and cry is raised by undesirable elements for pecuniary reasons, and in at least one instance, namely, the elimination of a large strip of worthless sandy land on the Minnesota National Forest, which had been cut over under forestry regulations, the Forest Service abandoned the principle for which the reserve had been created by Congress recently, the withdrawal of non-agricultural lands, and gave up its lands merely to make peace with an element notorious for its unscrupulousness. This same temptation to smooth down opposition by giving way in the question of land eliminations will be ever present. The physical facts alone must be the criterion of such eliminations if the Forest Service is to retain its prestige and be true to its trust. This danger affects most directly the central or Washington officials, who have to bear all the political kicks, wrestle with Congress, and secure appropriations from Congressmen who have a ready and

sensitive ear for complaints against Government officers or policy. The district officers are apt to be more strict in their tendencies on this question.

The problem next in importance is that of the timber resources. The accusation is made that foresters tend to overemphasize sustained yield and silviculture, and to neglect the problem of utilization and markets, upon which the entire structure rests. Here is where the idea of impracticability arises, which has attached its stigma to "working plans." The advocates of "practical" measures, recognizing the obvious economic needs of the present and the equally obvious necessity for marketing timber as a prerequisite of producing it, might even go so far as to ignore measures for securing reproduction on the grounds that the future value of such reproduction is too uncertain to be allowed to affect practical present problems. They might say, "Away with all this rubbish about regulation of yield!—we are engaged in the practical business of marketing timber—why not admit it!"

This question is fundamental. What are our National Forests for? If merely to market timber, why not permit the efficient private owners to handle the problem and put these Forests on the tax-lists of the various States? The policy which justifies the existence of our national holdings, as far as timber resources are concerned, is that of reproducing, growing, and regulating the output of timber and of making non-agricultural land productive.

There is no essential difference of opinion regarding the neecessity of conducting timber sales by methods intended to give the maximum opportunity for securing reproduction. The use of silvicultural terms such as "group selection" or "clear cutting with seed trees" is merely an aid in suggesting the means to be employed, which in final analysis comes down to handling each separate stand according to its specific condition, age, and form. The writer was surprised to note how closely the rules for marking longleaf pine in the South conformed to the most recent directions in the treatment of white-pine stands in Idaho. Any one who would advocate destructive timbering—*i. e.*, the disregarding of the problem of reproduction for National Forest timber—should also advocate the disruption of the Forests themselves.

Regarding the second problem, that of regulation of yield, we depart from the technical question of securing timber and enter the realms of pure business economics. Granted that we must grow all the timber possible, the question of the rapidity of its disposal must rest upon expediency and the theoretical conception of a sustained annual yield has caused much misunderstanding.

The principle of sustained yield rests on the best understood and most widely applied precept in business—that of a regulated output. The greatest benefits are derived from stabilized industry. This needs no explanation. Regulation of yield is the effort to stabilize the industry of forest production to cover the rotation or period of production of the raw material. But just as certain forms of business are of necessity fluctuating, and are conducted to secure the greatest profit, regardless of stability, so the marketing of forest products must be governed by opportunity and demands, by transportation facilities, and by the immediate needs of a developing community. At the same time—and here is where the forester applies the ideals which distinguish him from the so-often-termed "practical" manager—this marketing of timber should be far more than a blind process, governed solely by expediency and checked merely by measures to secure reproduction. The changes effected by timber sales are lasting, and the effect which such changes are producing upon the quality and condition of the raw material or timber capital should be definitely realized. No other large business would be conducted without careful consideration of the supplies of raw material and their probable duration and removal. The Forest Service cannot escape responsibility by urging that there is "plenty" of timber, that growth studies are at present impractical, or that as long as there is an immense surplus of overmature timber, no immediate attention need be paid to the questions of growth or regulation.

The Service has attacked this problem with characteristic vigor, and has pushed the work of timber reconnaissance as rapidly as funds will permit. Methods of topographic mapping have improved and results have been bettered with the development of a trained force of topographers. The continued use of the 4-rod or narrow strip, even on a 10 per cent or double-strip estimate, is probably necessary and sufficiently accurate when timber is sold entirely by actual log scale. As a method of determining the quantity of standing timber per forty, it is open to criticism as contrasted with the well-nigh universal system of private owners of actually examining, by some method or other, the entire area of each forty, but it is difficult to see how the Service could profitably modify this method.

The weak point, in the opinion of the writer, lies in the lack of data on increment. Whether or not it is immediately possible to cut timber, the Service should know what the condition of its forests will be at different periods in the future. This knowledge should be based on the age classes existing in the present stand and upon the probable damage which will take place in these age classes in the course of time. Such studies

must be coördinated directly with the data gathered in reconnaissance—mere "normal" yield tables are of little value—and they should be based on either area or diameters. The question of decadence—the average loss per year in forests of given age—is of even greater importance than that of the growth of young stands. It is absurd to dodge this issue by stating that in virgin forests growth equals decay. The growth of a crop of wheat would equal its decay if it has been permitted to rot on the ground, but, just as with forests, it makes a difference how the crop is handled and when the measurements are made. It is the business of the forester to know, for all portions of his forest, the rate of growth and of decay, and whether the one exceeds the other. T. T. Munger has produced tentative figures showing decadence for Douglas fir. D. T. Mason has hewed out a new path in the investigations of the effect of density of stocking on the growth per acre of lodgepole pine. Such figures on increment will substitute intelligent forecasts for complete lack of accurate prediction as to the future timber supplies on individual National Forests. They should not be neglected on the erroneous ground of impracticability or lack of utility.

When once the two factors of present volume or estimates and growth or change are even approximately determined for a forest area, the factor of maintenance of future yield can be given its due weight in the working plan for the forests or for a group of forests. We cannot ignore the fact that if the Government is to grow timber as a business, it is going to take a full rotation to accomplish it, nor the equally important fact that each forest should ultimately form a self-sustaining unit of annual yield. Where conditions permit it, sustained yield is the only practical plan of forest management, securing the most efficient and economical use of the forest resources. The knowledge of growth or increment enables the forester to not only measure his progress towards this goal, but to plan such progress intelligently.

These conclusions, the concentrated results of European experience, are naturally emphasized in theoretical instructions, often without the proper consideration of the economic conditions confronting the forester in this country and which must determine his measures in a large part. There has therefore been a natural reaction against the idea of sustained yield as wholly superfluous. In point of fact, the maintenance of a continuous future yield occupies the same relative importance in the business scheme as does the securing of reproduction in the technical plan of management. Where markets exist overmature stands must be heavily cut to save waste, but where possible to exercise any control whatever over the amount of the cut, the best rate of removal for such stands can be determined from

a study of the rate of decadence. Cutting cycles during the first rotation *should not be of equal length*, but should be *proportional to the amount of timber in each age class for whose removal the cycle is laid out.* Where no markets exist, the gathering of data can be postponed in favor of those forests which may be exploited at present. Where transportation costs demand concentration of the cut, these conditions will determine the character of regulation enforced. But in such case the foresters should know not only what relation the projected cut bears to the entire stand in the forest but also what prospect there is for returning to the cut-over area in the future—a matter dependent largely on increment. Business necessities affecting the entire group of National Forests—*i. e.*, the general working plan—may necessitate the concentration of present cutting on a few forests and the rapid exhaustion of the standing timber on such areas. This procedure can best be justified to the public, whose policy expressed in law is to prevent forest destruction, only by statistics of growth and by estimates covering the forests not yet exploited. Ultimately it may be hoped that the cut may not only be distributed more widely by improvement of the markets, but may be more and more brought towards the goal of accepted forest practice—equal annual output from each permanent forest. Let us not, in our reaction against "academic working plans," go to the opposite extreme of losing sight of these two fundamental principles, which alone distinguish forest management from destructive lumbering, namely, the reproduction of the forest and the orderly regulation of the forest enterprise by progress towards the goal of sustained annual yield.

A NEW ASPECT OF BRUSH DISPOSAL IN ARIZONA AND NEW MEXICO

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INTRODUCTION

The most important factor to be considered in administering a sale area is the conservation of reproduction, both present and future. The method of brush disposal over such areas is, therefore, of importance primarily from the reproduction viewpoint.

In District 3 of the Forest Service (New Mexico and Arizona) the dominant factor governing reproduction is the obtaining and conserving of an amount of soil moisture sufficient to germinate the seed and to carry the seedlings over the first four or five years of their existence. After this period the roots of the seedlings will usually have penetrated deep enough into the soil to survive the ordinary seasons obtaining in this district.

Apparently the normal annual rainfall is insufficient in many localities for the proper germination and subsequent growth of the seedlings during the first five years of their growth, unless the water which enters the soil is conserved by a protective covering of some kind on the ground, such as rocks and forest litter consisting of fallen needles, twigs, branches, trunks, etc. The protective influence of rocks on reproduction is very evident in many places where rocky points will have a good stand of young trees of all ages, while 40 or 50 yards away, on a soil devoid of rocks, no reproduction whatever can be found. The same protection against loss of moisture from the soil can be seen to a less degree over areas covered by forest litter and adjacent areas not so protected.

A good uniform reproduction on many areas in this district is dependent apparently upon a number of factors, among which are an abundant seed year, followed by one to several years of more than normal rainfall. Even under such optimum conditions the presence of a protective covering of forest litter, rocks, etc., is of great value in holding the surplus water in the soil, and thus making it available to the seedling over longer periods than it would otherwise be.

The value of the forest litter, leaves, twigs, branches, trunks, etc., in maintaining humus in the soil, in acting as a sponge to hold the rainfall,

in protecting against excessive evaporation by forming a superficial covering on the ground, and in protecting against excessive erosion must be admitted by all. Otherwise the theory must be abandoned that the presence of a forest on watersheds is absolutely essential for the conservation of the water flow, the prevention of undue erosion, and the consequent silting of the streams and water-power reservoirs.

The most dominant factor, therefore, in obtaining and perpetuating reproduction over a given area in this district is the conservation of the soil moisture. In addition to this, two other factors must be considered, viz., the danger to reproduction from fires and grazing. The danger from fire is most marked during the first two years after the area is logged, while that from grazing, especially by sheep and goats, will probably extend over ten or fifteen years.

Since the conservation of reproduction, both present and future, is the main factor to be considered in cut-over areas, it is of the utmost importance that all timber sales should be so handled as to retain a maximum of moisture in the soil and yet reduce to a minimum the danger from fire and grazing.

ULTIMATE DISPOSAL OF THE SLASH

There are two methods by which slash on a logged area is ultimately disposed of: (1) The natural method, a gradual rotting of the debris into humus, which finally becomes incorporated as a portion of the soil; (2) an artificial method, by burning the brush soon after the trees are cut. The second method destroys all the needles and smaller branches, thus removing all possibility of their forming a ground cover on the open areas exposed by felling the trees. It also kills a large amount of the young reproduction which is often already on the area, decreases the humus in the soil, and mineralizes the soil immediately under the large piles.

It is practically impossible to find a time in the year in District 3 when the brush piles can be burned without killing the young reproduction adjacent to the piles and without danger of the fires thus started getting beyond control. For this reason it is considered best on many areas to follow the natural method and allow the slash to be gradually rotted back to soil rather than to burn it. Such a method adds to the ground cover and to the humus in the soil, thus conserving the soil moisture so necessary to reproduction.

METHODS OF BRUSH DISPOSAL

At present there are four methods of brush disposal followed in District 3: (1) Piling, (2) scattering, (3) pulling, and (4) piling and burning. This article deals specifically with the rapidity with which the

brush rots and with the fungi causing this rotting under each of the first three methods of brush disposal enumerated.

In discussing the various methods of brush disposal it will be necessary to take into consideration the types of timber which are being cut. In District 3 the bulk of the timber is yellow pine (*Pinus ponderosa*); for this reason the factors affecting the brush disposal of yellow pine will be of much greater importance than those affecting the other timber, which consists chiefly of Douglas fir (*Pseudotsuga taxifolia*), white fir (*Abies concolor*), and spruce (*Picea* spp.).

The studies on brush disposal have been carried on in the Coconino and Tusayan National Forests in Arizona and in the Datil and Alamo National Forests in New Mexico on areas which had been logged from one to thirty-two years. The conclusions reached from these studies should be equally applicable to all of the other Forests in this district, since the underlying principles are identical and the climatic conditions are very similar.

YELLOW-PINE SLASH

Fungi Which Rot the Slash

Two main fungi were found to rot the yellow-pine slash. One begins work in the ends of the smaller branches and works downward toward the trunk. This is usually *Lenzites sæpiaria,* a common dry-rot organism prevalent throughout the United States. This is also the main fungus which rots decorticated cull logs and standing dead trees. It is a very slow-acting rot in this dry climate, especially in the trunks and branches. It produces a dry, brittle, charcoal-like rot that is very dangerous in times of fire, since the blazing fragments from the standing dead trees can be carried long distances by the wind.

The second fungus enters cull logs and the boles of the tree-tops, and extends from the boles into the larger branches (4 inches and up in diameter).

The usual form of the sporophores of this fungus belongs to the genus Poria. However, sporophores have been found with distinct pilei, so that ultimately this fungus may be classified under a different genus. For the present, in this discussion, it is called "the yellow-pine Poria." It is the main agent in rotting the cull logs and large branches of the yellow-pine slash.

Growth and Rot of the Yellow-pine Poria

The yellow-pine Poria begins its growth as a cottony layer of mycelium between the bark and sapwood of the felled tree. This cottony layer later

develops into a firm, white mycelial pad, which attaches the bark firmly to the sapwood. Extended field observations show that this fungus is very susceptible to temperature conditions. It usually starts near the top of the log on the warm side; that is, if the log is lying east and west, it will normally start on the south, or sunny, side. The rot gradually extends from its point of beginning near the top in all directions in the sapwood. During the first three or four years of its growth the rot moves rather rapidly longitudinally in the log and from the log out into the bases of the attached branches.

In warm localities logs may be found which show evidence of the early stages of this rot during the third year after the tree is cut, while in the small branches which have sufficient moisture the rot may become evident the second year.

The boles and branches of the tops usually rot more rapidly than logs and branches cut from the lower portion of the tree. This rapid rotting of the tops is probably due to their being very sappy and containing more nourishment for the fungi. Boles down to 4 or 5 inches in diameter in the tops usually retain sufficient moisture for the yellow-pine Poria to attack them, while severed branches of even a larger diameter are not attacked.

Lopped limbs of medium size (from 2 to 6 inches) dry much more rapidly than when left attached to the tree. Such dried-out lopped branches are not readily attacked by the yellow-pine Poria, since this fungus requires a certain amount of moisture as well as heat before it can gain a foothold in the timber. However, examples were found in damp localities where the lopped branches (4 or more inches in diameter) had also been rotted by the yellow-pine Poria, but as a rule medium and small-sized limbs depend for rotting, when severed from the tree, almost exclusively upon *Lenzites sæpiaria.*

The yellow-pine Poria rapidly rots the sapwood, producing a very wet, soggy rot, which will not burn on account of the enormous amount of water present in the rotting wood. It delignifies the wood and forms long strands of cellulose intermixed with the less-rotted wood. This cellulose is finally absorbed by the fungus. It does not produce definite pockets in the sapwood like those caused by *Polystictus abietinus.*

The yellow-pine Poria rots mainly the sapwood of the felled trunks and branches, leaving the heartwood practically intact. It produces the best type of rot possible in slash, since as long as it is acting on the logs the affected wood is very wet, and, therefore, cannot be burned. After ten or fifteen years, depending upon the location, this Poria finally destroys all that it can of the yellow-pine log, leaving the rotted sapwood in a loose,

stringy condition, which often falls away entirely from the heartwood. This rotted sapwood, when dry, if it catches fire, burns very quickly, and does not produce living cinders like the *Lenzites sæpiaria* rot.

If for any reason a log loses its bark soon after it is felled, the yellow-pine Poria will not attack it. Such logs get too dry on the outside for the fungus to gain a foothold in them. Dead standing yellow-pine trees are rarely attacked by the yellow-pine Poria, since the bark usually falls from such trees.

Fruiting Bodies of Yellow-pine Poria

The fruiting bodies of the yellow-pine Poria are usually located on the under side of felled trees in the form of a white encrusting layer. However, an occasional sporophore is found half way up on the sides of large logs. In such cases they are usually pileate. In most instances the fruiting bodies are formed directly on the outside of the bark, but a few have been found on decorticated logs.

Sporophores have been found on cull logs, on wind-thrown trees, on stumps, on lopped branches (4 or more inches in diameter), and occasionally on dead branches on living trees. They are very abundant on cull logs and large branches which are in direct contact with the soil.

In the field work so far the fruiting bodies of the yellow-pine Poria were found to be exceedingly rare on logs or limbs which were over 12 inches from the ground, although such logs and limbs might be uniformly rotted by the fungus. On limbs still attached to the tree, but over 12 inches from the ground, the fungus was not seen fruiting at all, while lopped limbs of the same size when on the ground often bore sporophores on the under side of them.

One of the most prolific sources of the fruiting bodies of the yellow-pine Poria was found in certain localities to be the prostrate boles, and the medium-sized and larger limbs (6 or more inches in diameter) which had been lopped. On the under side of such limbs the yellow-pine Poria fruits very abundantly, since these limbs, especially in rather damp locations, obtain a sufficient amount of moisture and the requisite amount of heat to produce a condition favorable to the growth of the fungus. In fact, where this Poria attacks a small branch, its sporophores appear one or two years earlier than they do on a log, apparently because the optimum temperature for the fungus is reached sooner in the small branch than in the large log with its greater abundance of water. On account of the large amount of food and moisture in the tops the yellow-pine Poria will be found fruiting more abundantly on the boles of the tops and large branches when they are lying directly on the ground than on logs and severed lower branches similarly placed.

The Yellow-pine Poria as a Heart-rot

The yellow-pine Poria is also the cause of a very serious and widely distributed heart-rot of living yellow pine in Arizona and New Mexico. It will, therefore, be necessary in considering the brush disposal of yellow pine to bear this fact in mind. This heart-rot is initiated by the spores from the fruiting bodies of the fungus infecting the dead branches on living trees and, through them, reaching the heartwood of the tree. The heart-rot produced by the yellow-pine Poria is new to the scientific world, and but little is, therefore, known as to its range.

This fungus is both beneficial and injurious—beneficial in rotting the slash and injurious in producing a heart-rot in living trees. It is, therefore, the part of wisdom to get the maximum of good out of it with the minimum of injury. The method of accomplishing this is (1) by felling all mature, overmature, suppressed, and defective trees, for such trees, on account of the large number of dead limbs on them, are highly susceptible to the attacks of this fungus, and (2) by preventing, as far as possible, the formation of all sporophores on the slash, thus reducing the chances of infecting the future reproduction. However, it is apparently impracticable at the present time to prevent all sporophores of the yellow-pine Poria from developing on the slash, since this would mean that all stumps, cull logs, and large limbs would have to be peeled, while the smaller branches (3 to 6 inches in diameter) would have to be burned. Furthermore, sporophores are also formed on wind-thrown trees and to a limited extent on the dead limbs of living trees.

Other Hosts of the Yellow-pine Poria

The yellow-pine Poria has been found in a limber pine (*Pinus flexilis*) as a heart-rot in the Datil National Forest, in the Mexican white pine (*Pinus strobiformis*) as a sap-rot in a cull log in the Alamo National Forest, and in a fallen tree of Chihuahua pine (*Pinus chihuahuana*) in the Chiricahua National Forest. It has not been found in Douglas fir, white fir, or spruce.

Other Fungi Attacking Yellow-pine Slash

In some localities the trunks and large limbs of the yellow pine are occasionally attacked by *Polystictus abietinus*. This fungus attacks only the sapwood and does not rot the yellow pine as rapidly as the yellow-pine Poria. It also seems to require more moisture than the yellow-pine Poria, since it is more frequently found in the moister and higher localities in New Mexico and Arizona.

Occasionally a yellow-pine log is rotted by *Fomes pinicola*. This fungus

requires more moisture for its growth than does the yellow-pine Poria or *Lenzites sæpiaria.* It is, therefore, not often found in pure stands of yellow pine in this district. In some moist locations, like draws and beds of cañons, this fungus is found attacking yellow-pine stumps. Over most of the yellow-pine areas, however, the stumps are usually destroyed by one of three fungi, the yellow-pine Poria, *Lentinus lepideus,* or a species of Poria which produces a rot with a very disagreeable odor.

The Rotting of the Slash in General

All of the needles in the tops of felled yellow-pine trees will fall in from three to five years, depending upon the locality in which the timber is located. The branches will gradually rot, and many of them will have fallen from the tree at the end of eight to twelve years. By the end of twelve to fifteen years, practically all of the branches, large and small, in the tops will have rotted and fallen to the ground. Also, most of the sapwood in the boles and cull logs which have been attacked by the yellow-pine Poria will have rotted in this time. The branches which project directly upward into the air seem to rot as rapidly as those which are nearer the ground.

Brush When Piled

Yellow-pine brush piles were examined, ranging from one to fifteen years in age. One of the requisites for proper piling of the brush by the Forest Service is that the piles shall be as compact as possible. It was found that during the first three or four years after the tree was cut but little rotting occurred even in the smaller branches. By the end of the fourth year, in most localities, all of the needles had fallen from the limbs which were exposed to the heat of the sun's rays, while the needles in the middle and the bottom of the piles, which were protected by the overlying brush, were still attached to the limbs. In six to ten years' time brush at the top of the piles, especially the small branches and twigs, had rotted to a considerable extent, but no signs of rotting were found at the bottom of any of the brush piles examined. In the bottoms of piles fifteen years old the small twigs in contact with the soil showed but little, if any, evidence of rot, while all the other branches were absolutely sound, although the brush at the top of the piles was in an advanced stage of rot.

As the brush at the top of the piles rots, the debris falls on the piles. The snows tend to compact this rotting debris into a kind of roof or cover to the lower layers of brush, thereby lengthening the life of the piles. Brush piles will not completely rot until the middle and bottom of the piles are exposed to the sun's heat. To accomplish this, the upper layers

must rot into small particles capable of being removed either by the winds blowing them away or by the rains washing them down to the bottom of the piles Just how long it would take to bring about such conditions is not known. Apparently, at least forty or fifty years must elapse before the ordinary compact brush piles will completely rot under the climatic conditions prevailing in Arizona and New Mexico. It was also found that the larger and more compact the piles are, the longer they will take to rot.

There is this factor to be borne in mind: When the brush is piled, there can be neither reproduction nor grass for grazing purposes developed beneath these piles as long as they exist. Since the brush in the bottom of piles fifteen years old was as sound as the day it was piled, these piles may be expected to last forty or fifty years, or even longer.

Brush piles are a standing fire menace during the entire period of their existence (40 or 50 years). A fire in a brush pile is probably more dangerous than under any other conditions, since the heat generated will be sufficient to kill all reproduction around the pile within a radius of at least the diameter of the pile, while the heated ascending currents of air caused by the fire will carry large quantities of burning debris into the air; in a high wind, these burning particles will be carried hundreds of feet, rapidly spreading the fire and making its control exceedingly difficult.

A fine example of the destruction caused by fire in brush piles was seen in the Alamo National Forest, where Douglas fir brush cut seven or eight years had been piled. The fire was so fierce over this area that it destroyed absolutely everything in its path, including reproduction and trees of all sizes. It was also very hard to extinguish on account of the wind whipping the blazing embers from the top of the piles hundreds of feet onto new areas.

The question at once arises as to why these brush piles do not rot, since the presumption is that brush in piles will be in a moister condition than when left on the tree or when scattered on the ground, and should, therefore, rot very rapidly.

Before discussing the reasons for this failure of the brush piles to rot, it will probably be advisable to consider the other methods of brush disposal, to-wit: Scattering, pulling, and piling and burning. On account of the principles involved, the rotting of the pulled brush will be discussed first.

Brush When Pulled

By pulling is meant that the brush in the tops of the felled trees is not lopped, but is left exactly like the tree top fell, except when this top falls on or near reproduction. When brush is too close to reproduction, it is

pulled away from the young trees to decrease the danger from possible fire, hence the term "pulling."

The ideal method of brush disposal would be for the needles, twigs, and small branches to rot down as rapidly as possible, thus removing the danger from fire, while the trunks and large branches should be so rotted that they would not be readily susceptible to fire and yet be gradually carried back to the soil, thereby conserving the soil moisture by adding a certain amount of humus to the soil each year. Such a condition of affairs results when the brush is pulled—that is, when the tops are left just as they fall, with the limbs still attached to them.

When the limbs in the tops are not lopped, the danger of fire killing the reproduction is less than when they are lopped and either piled or scattered, since the branches of the tops extend in all directions in the air, and, therefore, do not usually form as intense a heat as the piles, nor will they cover as much area as when the brush is scattered. After the needles have fallen, which will be from three to five years, the danger from fire in brush which has been pulled will be practically nothing.

When the branches are left attached to the tree there is sufficient sunlight, at least under the outer edges of the tops, for reproduction to come in; after the needles have fallen, seedlings can grow anywhere under the felled tops. The attached branches extending in all directions from the tops afford a splendid protection against grazing, especially of sheep and goats, which are apparently the most destructive to young reproduction. This protection will extend over a period of ten to fifteen years, since it will take this length of time for the limbs to finally rot away from the tree. Even then, the heartwood of many of the large branches and the small ones which are pitchy will not be entirely rotted, and will, therefore, continue to afford protection for a still longer period.

It is much better for the future health of the forest to leave the limbs attached to the tops, under which conditions they would still be rotted by the yellow-pine Poria, but would rarely, if ever, produce the fruiting bodies of the fungus. The limbs will also often hold the boles of the tops far enough from the ground to prevent the Poria from fruiting.

In a yellow-pine area logged thirty-two years ago, where all of the tops were left unlopped, the slash has all disappeared except the heartwood of the trunks and large limbs and an occasional log with the sapwood well rotted, but still present. Reproduction on this area is very fine.

Brush When Scattered

When the brush is lopped and scattered it rots much quicker than when piled, but not as rapidly as when left attached to the tops. In

some localities this difference in the rapidity with which the limbs rot which are still attached to the tree, and those that are cut off is very marked. On the Coconino National Forest near Flagstaff, Arizona, in six-year-old slash, lopped yellow-pine limbs (3 to 6 inches in diameter) were found apparently as sound as the day the tree was felled, while limbs of the same size still attached to the tops from which the severed limbs came were well rotted by the yellow-pine Poria.

When brush is scattered, it prevents to a great extent the coming in of seedlings under it during the first three to five years after it is scattered or until the needles have fallen. The scattered brush will also afford some protection against grazing during probably the first five or six years. After that the protection would be but little due to the rotting of the leaves and smaller branches and to the scattered and prostrate condition of the remainder. If a fire occurs during this time it would practically destroy all of the young reproduction where the brush was scattered.

Brush When Piled and Burned

On one of the yellow-pine areas visited which had been logged about nine years, three methods of brush disposal had been followed: (1) piling, (2) scattering, and (3) piling and burning.

An examination of this area showed that the brush on the tops of the piles had rotted down, but the branches on the inside and at the bottom were still sound. The scattered brush had also rotted fairly well, except some of the medium-sized branches which had dried out too much for the yellow-pine Poria to attack them. Most of the sapwood on the cull logs was rotted by the yellow-pine Poria. The areas on which the brush was piled and burned are still naked and have no reproduction whatever on them, while the adjacent areas have a fair amount of reproduction. Also in many instances the humus in the soil covered by the brush piles was destroyed and the soil mineralized. On another forest where the brush piles had been burned some six years, the burned areas now have a few one-year-old seedlings on them. It is very problematic whether these unprotected burned spots will retain sufficient moisture to carry the seedlings now on them over the next five years.

DOUGLAS FIR SLASH

In the Douglas-fir slash the trunks and large limbs (6 inches and up in diameter) are usually rotted by what the writer calls "the Douglas-fir fungus" (*Fomes pinicola*), while the twigs and small branches are rotted by the dry-rot fungus (*Lenzites sæpiaria*). The Douglas-fir fungus rots

both the sap and heartwood of the attacked trees. It is a carbonizing rot which converts the wood into a mass of brown, brittle, more or less cubical blocks like charcoal. The rot in the cull logs is usually very moist, and therefore difficult to burn. However, when a log rotted by this fungus once catches fire, it sends forth immense volumes of smoke, with but little flame, and is not easily extinguished on account of the charcoal-like character of the rotten wood. Dead standing Douglas-fir trees which have this rot are exceedingly dangerous in times of fire on account of the fire running up to the tops of these dead trees and fragments of the burning rotten wood being blown long distances by the wind.

The Douglas-fir fungus begins in the boles of the trees and extends, like the yellow-pine Poria, from the boles into the attached branches (4 or more inches in diameter). This rot from the bole of the tree does not extend as far into the medium-sized branches of the Douglas fir as does the yellow-pine Poria into the yellow pine.

The branches of the Douglas fir when cut from the tree do not seem to be attacked by the Douglas-fir fungus, unless they are very large (10 or more inches in diameter). This is probably due to the fact that the water content of the branches which are severed from the tree is too small to permit the growth of the Douglas-fir fungus. The thickness and texture of the Douglas-fir bark on the living tree is such that, after felling, the cull logs and boles of the tops retain much more moisture than yellow pine under the same conditions. This is one of the reasons why *Fomes pinicola* is usually the fungus which attacks the Douglas-fir logs and large limbs.

The dry-rot fungus (*Lenzites sæpiaria*) begins in the outer ends of the Douglas-fir branches exactly as it does in the yellow pine, and slowly rots the twigs and small branches of the Douglas fir downward towards the trunk. It is also the fungus which generally rots the small and medium-sized lopped branches, and is occasionally found attacking decorticated Douglas-fir logs.

Some times a Douglas-fir log is attacked by *Fomes roseus* and *Polystictus abietinus.*

Brush When Piled

Exactly the same condition of affairs was found in Douglas-fir brush piles as was found in the yellow-pine piles; that is, the brush at the top of the piles, where it was exposed to the heat of the sun, was in all stages of rotting, while the brush in the centers and the bottoms of the piles was not rotted at all. This was found to be the case in Douglas fir which had been piled for fifteen years, since samples of perfectly sound Douglas-fir

branches were taken from such piles, while the top portion was fairly well rotted.

Douglas-fir brush which had been piled seven years was examined, and but little evidence was found anywhere in these piles of any rotting. However, many of the branches and twigs at the tops of the piles showed evidence of *Lenzites sæpiaria* rot in its earlier stages. It would seem, therefore, that the Douglas-fir brush, especially the small limbs and branches, rots much more slowly than the yellow pine.

Brush When Pulled

The pulled Douglas-fir brush was found to rot exactly like the pulled yellow-pine brush. The branches attached to the felled tree-tops were rotted by two fungi, (1) the Douglas-fir fungus which extends from the trunk into the bases of the branch, and (2) the dry-rot fungus (*Lenzites sæpiaria*), which rots the tips of the branches. When the branches are cut from the tree, they dry out so rapidly that only one fungus (*L. sæpiaria*) can attack them.

Brush When Scattered

The small and medium-sized branches of the Douglas-fir slash when lopped and scattered are usually rotted by only one fungus (*Lenzites sæpiaria*), while the cull logs and boles of the tops are rotted by the Douglas-fir fungus (*Fomes pinicola*).

WHITE-FIR SLASH

A very small amount of white-fir brush was found on a few areas. The cull logs and boles of the tops of the white fir were usually rotted by what the writer calls "the white-fir fungus" (*Polystictus abietinus*). This is a delignifying fungus which produces a rather damp, pocketed rot limited mainly to the sapwood. It apparently requires more moisture than the yellow-pine Poria, and is, therefore, not as common in the drier and warmer locations. This rot first attacks the trunk, and then moves from the trunk into the attached branches, while the twigs and the tips of the branches are attacked by the dry-rot fungus (*Lenzites sæpiaria*). When the white-fir limbs are severed from the tree, they usually dry out to such an extent that the white-fir fungus (*Polystictus abietinus*) rarely attacks them—at least over the areas examined. The severed branches are, therefore, dependent for rotting upon the dry-rot fungus (*Lenzites sæpiaria*).

White-fir brush piles were examined which had been cut for ten years. The same condition was found in these piles as in the yellow pine and

Douglas fir, namely, that while the brush at the top of the piles was in all stages of rotting, the branches, and even the small twigs at the bottoms of the piles, were absolutely sound.

Occasionally a white-fir log was found attacked by the Douglas-fir fungus (*Fomes pinicola*).

BLUE-SPRUCE SLASH

A few felled trees of blue spruce (*Picea parryana*) were found. The fungi attacking these were practically the same as those on Douglas fir, consisting mainly of *Fomes pinicola* and *Lenzites sœpiaria.*

PIÑON SLASH

But little piñon slash (*Pinus edulis*) was seen, and that seen was not in the regular piñon type, but was mixed with yellow pine. Three fungi were found rotting the piñon, *Lenzites sœpiaria, Polystictus abietinus,* and *Polyporus cinnabarinus*. Further investigation will have to be conducted before any accurate conclusion can be drawn as to which fungus is responsible for the main rotting of the piñon slash.

WHY THE BRUSH PILES DO NOT ROT

The presumption has obtained that slash would rot better when piled than under any other conditions, since it was thought that the brush piles would be moister, and this condition would be conducive to a rapid rotting of the brush. This may be true in the warmer and more humid regions of the United States, but is certainly not the case in Arizona and New Mexico. Apparently moisture is not the determining factor in the rotting of the brush piles in these two States, since the brush at the bottoms of the piles contains at least as much moisture as that at the tops of the piles, yet piles were found whose tops were thoroughly rotted while the bottoms were as sound as the day they were piled.

The only explanation at the present time of the brush not rotting in the bottoms of the piles seems to be as follows: In Arizona and New Mexico all of the timbered areas are at rather high altitudes (7,000 feet and up). This means that during the greater portion of the year the temperatures over the wooded areas will be rather low. The actively growing period of the fungus will, therefore, be limited more or less to the months of June, July, August, and September. Also, the question of moisture will play an important part in this district, since the dryness of the atmosphere in New Mexico and Arizona is very pronounced. The

period of time, therefore, during which these fungi can obtain the requisite amount of moisture and a sufficient amount of heat at the same time is very short.

It would appear, for the reasons just given, that the brush at the bottoms of the piles is not rotted, mainly because it does not receive the requisite amount of heat, since it is shielded from the sun's rays throughout the year by the brush above. It therefore will not rot until conditions arise which will permit the sun's rays to reach the bottom of the piles, and thus supply the necessary heat. Such an explanation at best is only tentative, and is offered in lieu of a better one. Detailed investigations now under way may show that temperature is not the dominant factor. However, instance after instance was found where long limbs, with both ends protruding from brush piles and their centers completely buried by the brush, had rotted at the ends, while the protected part was unrotted. Brush when heavily shaded also rotted much slower than similar brush exposed to the sun's heat.

It is very probable that fewer spores of these wood-rotting fungi reach the bottom of the piles than the top; still a sufficient number would certainly be washed down by rain and blown in by the winds to thoroughly infect the brush in the bottom, if the other factors necessary to fungous growth were present. The failure of the brush at the bottom of the piles to rot cannot, therefore, be attributed to the absence of spores.

Many of the brush piles of yellow pine are so completely made that for the first few years at least much of the water which falls on these piles does not reach the bottom. Still a sufficient amount of water penetrates the piles during the rainy season to wet them from top to bottom. The writer has examined a large number of brush piles of all ages, ranging from one to fifteen years old, and has yet to find one that was not thoroughly wet at the bottom after the rainy season began. In many of these piles the small brush and twigs at the bottom were so saturated with water that they were very flexible and easily bent (yet were perfectly sound), while the brush at the top was in all stages of rotting.

ROTTING OF SLASH IN THE OTHER DISTRICTS

A careful examination of the rotting of the slash in all the Western Forests where the timber is limited to high elevations (above 6,500 feet) may show the same conditions that obtain here, to-wit: (1) That the most important factor in the rotting will probably prove to be temperature rather than moisture; (2) that the brush on an unlopped tree-top will rot quicker, or at least as quickly, as when lopped and scattered;

(3) that when the brush is piled the limbs at the bottom of the pile will not rot for years, due apparently to their being protected from the heat of the sun's rays.

Of course, it is entirely possible that the slash in the other Western Forests, especially those in the Northwest, may be rotted by entirely different fungi and by fungi capable of rotting the brush at much lower temperatures than those found in the Southwest.

SUMMARY

(1) When the tree-tops are left unlopped, the brush rots quicker than when either scattered or piled. This is due to the fact that two types of fungi rot the brush, one entering the trunks and extending from the trunks into the attached branches, the other entering the tips of the branches and extending down toward the trunks.

(2) When the tops are not lopped, they encourage reproduction beneath them by the protection afforded by their limbs projecting in all directions, thus forming a slight shade for the seedlings and protecting them from stock for ten to fifteen years.

(3) Fewer sporophores of the yellow-pine Poria are formed on the branches left attached to tree-tops than when the branches are severed and lying on the ground. There are, therefore, fewer spores discharged into the air to endanger the future health of the forest.

(4) When the tree-tops are lopped the brush in most instances does not rot as rapidly as when left attached to the trees. This is due to the severed branches losing water through the cut ends, and thus becoming too dry for the fungus which attacks the trunk to gain a foothold in the severed branches. The branches which are scattered on the ground do not get enough moisture from the soil to balance the loss of moisture due to being severed from the tree. Also, when branches are attached to the tree they have two opportunities for infection, one through the trunk and the other from the spores falling on the branches themseelves, while, if they are lopped, they have only one.

(5) When the brush is piled, it will probably take forty to fifty years for the piles to completely rot, due apparently to the fact that the brush at the bottom of the piles does not get the heat from the sun's rays, and fungi are, therefore, unable to gain a foothold in this brush.

(6) Brush when piled remains a standing fire menace over a long period of time, probably forty or fifty years.

(7) Brush when piled excludes all possibility of reproduction or grass under the brush during the existence of the piles.

(8) Each species of tree has its special fungus which rots the trunks and large branches. However, several fungi of secondary importance often aid the main fungus.

(9) Four fungi are the main agents in rotting the slash in Arizona and New Mexico, viz., the yellow-pine Poria (*Poria* sp.), the Douglas-fir fungus (*Fomes pinicola*), the white-fir fungus (*Polystictus abietinus*), and the dry-rot fungus (*Lenzites sæpiaria*).

(10) The yellow-pine Poria, in addition to rotting the slash, also produces a serious heart-rot in living yellow-pine timber.

(11) *Fomes pinicola, Polystictus abietinus,* and *Lenzites sæpiaria* attack only dead and felled timber over the areas examined in Arizona and New Mexico.

(12) *Lenzites sæpiaria* and *Fomes pinicola* are carbonizing fungi—that is, they produce a brown, brittle, charcoal-like rot. Such rots are very dangerous in time of fire, since they burn like charcoal, and, being very light, can be carried long distances by the wind.

(13) *Polystictus abietinus* and the yellow-pine Poria are delignifying fungi—that is, they extract the lignin from certain elements of the wood, leaving cellulose, which is later absorbed by these fungi.

(14) *Lenzites sæpiaria* seems to rot the twigs and branches when attached to the tree as rapidly as when they are lopped and scattered on the ground. This means that no real advantage in the rotting of the twigs and small branches is gained by their being on or near the ground.

BRUSH DISPOSAL IN LODGEPOLE-PINE CUTTINGS

BY PROFESSOR D. T. MASON

University of California

Nearly all of the present cut from lodgepole-pine stands consists of green timber, in connection with which there is being spent an average of about fifty cents per thousand feet for piling and burning brush. The average cut per acre is about 10,000 feet, resulting in a cost of about $5 per acre for brush disposal.

The purpose of this expenditure is essentially to reduce the danger from fire. Are we getting our money's worth?

Owing to the comparatively dry climate of the region, with an annual precipitation of from 18 to 25 inches, lodgepole-pine brush decays very slowly. When undisturbed, needles last 3 or 4 years; twigs, 8 or 9 years; windrows, probably 40 years; pieces 6 to 8 inches in diameter, about 60 years. The thin bark of lodgepole trees protects them only slightly from fire damage, and they are easily killed by a hot fire in debris around their bases. Light grass fires, however, cause fire scars, but do not ordinarily kill the trees. The ground cover under lodgepole stands in Montana is generally made up of weeds and grass more or less suitable as forage for grazing animals. Even in those stands in which the ground cover consists of huckleberry or other unpalatable growth, there are frequent open areas affording excellent forage. In the lodgepole region a fire can cover a large area only if transmitted by the ground cover. Where, through lack of grazing, dry grass and weeds have accumulated year after year, fire will run quite rapidly. Crown fires are comparatively rare, and occur only where there is a considerable amount of debris on the ground, making a sufficiently hot fire to jump into the tops. The trees are not festooned with moss, as in moister regions.

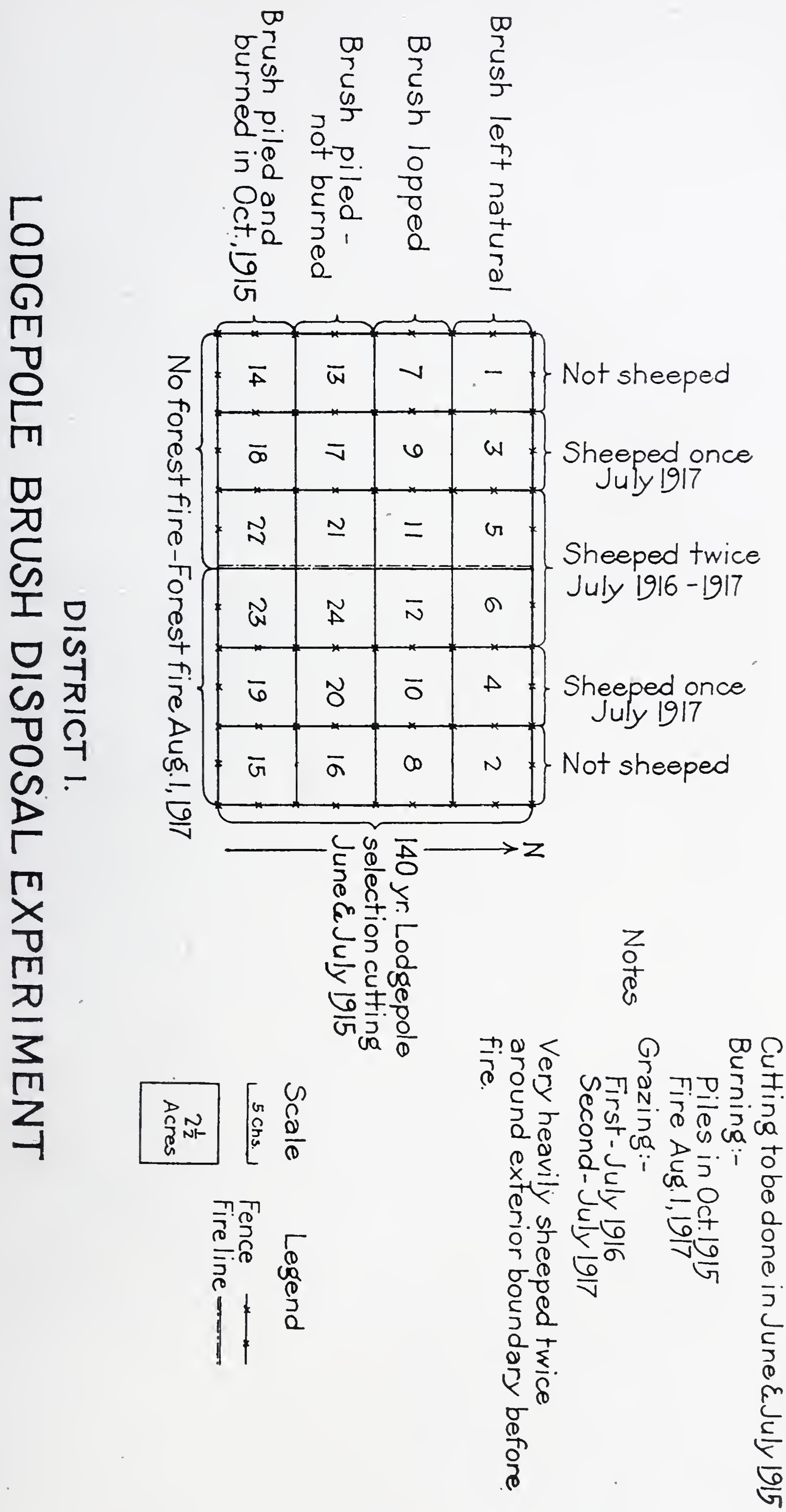
Grazing reduces the fire hazard greatly by removing the forage. Furthermore, grazing animals tramp to pieces and literally wear out the debris, whether it is scattered brush, windrows of brush, or tree trunks. A fire burning where there is disintegrated debris is not nearly so hot and travels much more slowly than a fire in untouched slash, and in damage would be comparable to a fire burning in rather heavy grass, although it would not travel as rapidly as a grass fire. Sheep are more effective in removing the forage and in grinding away the debris than are horses or cattle. Near Butte, on the Deerlodge Forest, sheep have been deliberately used to work lines through especially dangerous areas of down timber. In

one season this has greatly reduced the danger of fire, and without injury to the sheep. In Montana it has been observed very frequently that fires go out upon reaching the edge of a well-grazed area. This is especially striking where there has been grazing on one side of a fence, but not on the other. Several hundred sheep are used by the Potlatch Lumber Company to reduce the fire danger in their yard. The safety of areas unsuitable for grazing may be greatly increased by a fairly complete use of forage on adjoining areas, for such use will serve to isolate the former. This will be especially effective where the non-grazing areas are broken into small units by the parks occurring here and there, as is usually the case in the region. Furthermore, animals grazing near such non-grazing areas will cross them here and there, trampling them rather effectively.

The products of a lodgepole stand ordinarily yield a stumpage return of approximately $25 per acre. Assuming that equal financial returns can be secured at 30-year intervals following the first cutting, the loss from fire in case of total destruction of the timber left would be about $16. This figure is secured by discounting to the present, at 3 per cent interest, an equal financial return at the end of 30, 60, and 90 years, respectively, without allowance for cost of protection, but figuring that decreased cut will be offset by increased value. The loss in connection with water-shed protection would be very small, since reproduction would be secured immediately. The actual damage, however, would scarcely exceed $12, since a considerable amount of the fire-killed timber would usually be salvaged.

The distribution of age classes in lodgepole stands, fire scars, etc., convince one familiar with the region that before the forests were protected from fire, and before there was much grazing in Montana, fires occurred, on the average, at intervals of from 40 to 50 years. Under those conditions there was about one chance in 50 that an average acre would burn over in any average year. The attached table gives the fire record for the past 7 years for the National Forests in the Montana portion of the lodgepole region. For the years previous to 1908 there are no available records. During this period there have been two exceptionally dangerous fire seasons—1910 and 1914—so that it may be stated without fear of contradiction that the average fire danger during this period has been greater than would be the case for a continuous long period of, say, 100 years. The table indicates that, under the conditions existing during the past 7 years, the chances have been 1 in 279 that an average acre would burn over in an average year. The fire-protection system for the Forests listed in the table is now much more efficient than it was in 1908, and it is safe to say that it will increase in efficiency in the future.

Another factor of even greater importance is grazing. In the table are


Brush left natural
Brush lopped
Brush piled - not burned
Brush piled and burned in Oct., 1915
Not sheeped
Sheeped once July 1917
Sheeped twice July 1916 - 1917
Sheeped once July 1917
Not sheeped
1 3 5 6 4 2
7 9 11 12 10 8
13 17 21 24 20 16
14 18 22 23 19 15
No forest fire - Forest fire Aug. 1, 1917
N
140 yr. Lodgepole selection cutting June & July 1915
Notes
Cutting to be done in June & July 1915
Burning:-
Piles in Oct. 1915
Fire Aug. 1, 1917
Grazing:-
First - July 1916
Second - July 1917
Very heavily sheeped twice around exterior boundary before fire.
Scale
5 Chs.
2½ Acres
Legend
Fence
Fire line
DISTRICT 1.
LODGEPOLE BRUSH DISPOSAL EXPERIMENT

grouped those Forests which are well grazed, or which are stocked to 0.7 or more of their estimated carrying capacity, and those whose stocking does not exceed 0.6 of their capacity. In the first group, 0.78 stocked, the chance of fire burning over an average acre in an average year during the period has been 1 in 1,109; in the second group, 1 in 123. A further study of the areas burned over during the period reveals the fact that in most cases in which the burned area for any one fire exceeded 100 acres, the area was at least partly suitable for grazing, but had not been grazed at all or had been grazed only slightly. This holds true for both classes of Forests mentioned above. Data which cannot be presented in detail here indicate that over 80 per cent of the 284,713 acres burned over during the period was practically ungrazed. During the period the number of sheep grazed on the Forests has increased 31 per cent, but the number of cattle and horses combined has decreased 12 per cent; so that, considering the sheep with the horses and cattle in the ratio of 1 to 5, the grazing use has increased 15 per cent.

Although the Forests will become more fully stocked and the protection system more effective in the future, let us assume that for fairly well grazed Forests the chance of a fire burning over an average acre in an average year is 1 in 1,000. We are, then, spending $5 per acre to prevent a damage of $12 per acre, which is likely to happen only once in 1,000 years, if the land is 0.7 or more grazed and if the present degree of protection is afforded. In a country at all suitable to grazing, sheep will probably practically eliminate brush in 5 years, reducing the fire danger to normal for an uncut stand. Where it is practicable to graze sheep, then, the dangerous condition caused by the cutting may be eliminated in about five years. The probable damage or hazard is, then ($12 ÷ 1,000), x 5, or 6 cents per acre. We are justified in spending no more than we will probably save by the expenditure. The present expenditure of about $5 per acre is, therefore, not justified where it is practicable to dispose of the brush by properly regulated grazing. The expenditure of even as little as 5 or 10 cents per thousand feet for lopping cannot be justified, even though it will greatly aid grazing to disintegrate the brush, for it would be at a cost of 50 cents to $1 per acre. Furthermore, the saving of the 6 cents, even if the brush could be removed without a cent of expense, is probably fully offset by the value of the increased power of the forest to conserve moisture where the brush is not burned. The character of the soil is also improved in the long run.

Where there is only a little grazing, the range can be allotted with the particular object of reducing fire danger on sale areas to normal rapidly. Sale areas should be grazed only until the brush is rather thoroughly disintegrated, after which grazing should be prevented or greatly restricted

for from 6 to 10 years. The 5-year period should be devoted to excessively heavy grazing, which would mean a slight loss of time due to the failure of reproduction to start promptly, and would destroy some advance growth; on the other hand, it would result in a more even and satisfactory restocking than where grazing is absolutely prohibited after the cutting, and the loss of advance growth would probably be equally great from the burning of brush piles.

Where grazing is not now practicable on a cut-over area the chances of fire are certainly not more than 1 in 100, for the present system of protection has at least halved the former danger. In this case, however, a period of from 20 to 40 years will probably elapse before the danger has been reduced to normal. In this case the probable loss is ($12 ÷ 100) x 20 or 40 = $2.40 or $4.80, or a considerable part of the cost of piling and burning the brush. The advisability of the outlay in even this case is doubtful, since the system of protection will certainly become more efficient, and grazing will probably be feasible in a few years in many places where it cannot now be practiced, owing to lack of stock.

In order to determine much more definitely the interrelations of brush disposal, fire hazard, grazing, and reproduction, it is planned to perform the experiment graphically outlined in the attached diagram. This experiment can be undertaken near Bernice, on the Deerlodge Forest, where suitable market and grazing conditions exist, at an expense of about $150 for fencing and $50 for fire control.

If the results of the experiments outlined prove nearly as satisfactory as appears probable, the piling and burning of brush should be discontinued in those portions of the lodgepole-pine region where grazing is feasible, provided that every effort is made to eliminate the fire danger after cutting as rapidly as possible by a period of heavy grazing, which should be followed by one of greatly restricted grazing to permit new reproduction to get a good start. Where grazing is not considered practicable in the near future, the present plan of piling and burning the brush should be continued until the results of the proposed experiment are definitely known.

It is suggested that the preparation of similar tables and data for other forest types will give interesting light on the economics of the present brush-disposal practice. The data given are also suggestive of the possibilities of reducing fire hazard by properly controlled grazing in especially dangerous places, as along railways, highways, the edges of areas of slash, and the like. Where there is insufficient stock available to graze generally over an area, they could be used along strategically located lines to break the area up into small units. Private timber operators who need fire protection at low cost should look into the possibilities of sheep grazing.

TABLE 1—*Fire record, lodgepole region, Montana*

Forest.	Area burned—acres.									Forest gross area, 1,000 acres.	Per cent of gross area burned each year.	Number of years to burn over entire forest — basis 7-year average.	Degree to which grazing capacity stocked in 1914.
	1908.	1909.	1910.	1911.	1912.	1913.	1914.	Total 7-year period.	Average annual.				
Absaroka	181	1,658	2,200	33	....	....	132	4,204	601	988	.061	1,644	.8
Beartooth	....	....	640	45	50	....	5	740	106	682	.016	6,434	.8
Beaverhead	15	....	7,381	109	....	2	4,700	12,207	1,744	1,365	.128	783	.8
Bitterroot	213	620	32,100	721	....	236	2,000	35,890	5,127	1,155	.444	225	.2
Deerlodge	2,406	28	2,893	8	10	507	1,933	7,785	1,112	964	.115	867	.75
Gallatin	163	412	8,962	10	2	....	191	9,740	1,391	909	.153	653	.6
Helena	1,071	....	8,000	4	17	282	206	9,580	1,369	920	.149	672	.8
Jefferson	1,120	....	8,122	14	6	2	796	10,060	1,437	1,176	.122	818	.7
Lewis and Clark	1,551	4	142,000	....	6	5	3,760	147,326	21,047	826	2.547	39	.4
Madison	145	....	199	5	....	42	21	412	59	1,036	.006	17,559	.8
Missoula	7	2	43,957	9	....	10	2,784	46,769	6,681	1,330	.502	199	.3
Grand total	6,872	2,724	256,454	958	91	1,086	16,528	284,713	40,674	11,351	.358	279	.62
Total[1] (7 Forests)	4,938	1,686	29,435	218	83	835	7,793	44,988	6,428	7,131	.090	1,109	.78
Total[2] (4 Forests)	1,934	1,038	227,019	740	8	251	8,735	239,725	34,246	4,220	.811	123	.36

[1] For the Absaroka, Beartooth, Beaverhead, Deerlodge, Helena, Jefferson, and Madison, for none of which the degree of grazing utilization falls below 0.7 and averages 0.78.

[2] For the Bitterroot, Gallatin, Lewis and Clark, and Missoula, for none of which the degree of grazing utilization exceeds 0.6 and averages 0.36.

The degree of stocking of most of the Forests has been gradually increasing up to 1914.

SOME NOTES ON FOREST ECOLOGY AND ITS PROBLEMS

BY RICHARD H. BOERKER

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While recently engaged in some special silvical work, I had occasion from time to time to jot down a few ideas concerning forest ecology in general and silvical problems in particular. Without materially changing these notes, I am offering them in the form of a paper as suggestions for the purpose of fostering discussion and investigations along these lines.

At this stage of American forestry, when many diversified silvical problems are being attacked, it may be desirable to get a bird's-eye view of the whole field, and especially to point out the scope, the methods, and the aims of this new science. The field is extremely large; in fact, it is difficult to delimit, yet that fact does not detract from the value of a discussion of its various subdivisions, their relation to each other, and their relative importance. If nothing else, such a presentation of the subject might develop in the reader's mind a little of what might be called "scientific perspective"—that is, an appreciation of which problems are important and which are not, which are simple and which complex, and finally what should be the logical order in which they should be taken up for solution.

DEFINITION AND CONCEPT OF FOREST ECOLOGY

Forest ecology, or silvics,* may be defined as the science dealing with the reciprocal relations between trees and forests and their environment. The broadest conception of this definition would include the influence of climate, soil, animals, and other plants upon the individual tree and the forest, and, reciprocally, the influence of the forest upon climate, soil, plants, and animals. Most of these factors are easily identified as being parts of the environment, but how far the relation of animals to the forest should be included in this study is rather an unsettled question. For example, certain phases of forest entomology, forest pathology, or even grazing might or might not be considered a part of silvics, depending upon the point of view one takes. Due to its intimate relations to many

*Although these two terms are used indiscriminately in this paper, the author thinks that forest ecology has a broader significance than silvics, and that when the scope of the subject is appreciated either the concept of the term silvics will be broadened or the term forest ecology will replace it. As it is generally used, the term silvics does not aim to include the morphological or physiological phases of ecology nor the study of habitat factors.

branches of botany and other sciences, forest ecology is difficult to delimit. The dividing line between forest ecology on the one side and the morphology and physiology of woody plants on the other is not distinctly drawn. Likewise, who will say where silvics ends and where such sciences as dendrology, meteorology, physics, or chemistry begin?

Generally speaking, silvics is the study of causes, namely, the environmental factors, and their effects, namely, the tree and the forest, and their relation to each other. There are two phases of forest ecology, the one dealing with the relation of the environment to the structure and behavior of the tree (autecology), and the other dealing with the relation of the environment to the forest (sinecology). In other words, the science deals with the morphology and the physiology of both the tree and the forest, if I may be allowed to use these terms in connection with forests. It is important to understand that both the tree and the forest have characteristic form, structure, functions, and life processes, for the forest is not an aggregate of trees, but a tree entity, a living organism capable of response to environmental factors like the individual tree. The forest formation, like the tree and the forest, is also a complex organism and behaves in accordance with well-defined laws. The influence of the forest upon the environment is another phase of this large subject, and this is known under the name of "forest influences."

Forest ecology occupies a definite place in the field of botany as well as forestry. The relation of silvics to dendrology on the one hand and silviculture on the other is a very intimate one. Dendrology is simply systematic botany dealing with trees, including their identification, classification, and botanical description. Obviously this knowledge is of fundamental importance to silvics. Silviculture is the economic application of silvical facts and relations for the purpose of producing timber. It might be said, then, that silvics is the connecting link, so to speak, between dendrology and silviculture. Silvics and silviculture are interdependent, for the ultimate purpose of silvics is to discover facts which will be of use to silviculture. In other words, silvics furnishes the tools with which silviculture works. Silviculture without silvics is inconceivable; silvics without silviculture would be useless. Silviculture is as dependent upon forest ecology or silvics as agriculture is upon plant ecology. The life of both of these human occupations depends upon purely scientific botany. For this reason silviculture is often spoken of as applied botany "par excellence."

METHODS, SCOPE, AND IMPORTANCE OF FOREST ECOLOGY

The methods of securing silvical knowledge do not differ materially from those used to obtain knowledge in other branches of learning. For-

merly direct observation was the means chiefly adopted in order to extend the fringe of knowledge, but at the present time the method of advance by way of experiment has spread almost to every branch of science, and especially to botany and forestry. There are therefore two general methods in use for securing silvical facts, namely, the empirical and the experimental. In the empirical method we learn facts by practice—that is, by doing things over and over again. It is largely an observational study of effects. Compared with the experimental method, it is laborious and expensive. In the experimental method we learn facts by intensive, carefully planned and executed experiments. Compared to the empirical method, these experiments run over a short period of time and they are on a smaller scale. It is the purpose of the experimental method to correlate cause and effect by scientific methods and study. In this method the securing of silvical facts and relations is a primary consideration; in the empirical method this feature is secondary, for in most cases the desire to obtain practical results overshadows the desire to obtain valuable silvical data. These two methods are so well known that further comment or illustration seems unnecessary.

In the past most of our silvical data have been obtained by the empirical method. In the study of the tolerance of trees, for example, we have employed principally empirical methods, while the real solution of the problem undoubtedly depends upon experimental methods. While the former method will undoubtedly continue its usefulness to a limited extent, one must not overlook the fact that scientific silviculture is beginning to replace silviculture based on practice; that scientific silviculture demands scientific silvics, and that the only truly scientific method for obtaining silvical information is by study and experiment.

Since trees and forests are the highest expression of plant life, ecology may expect to find in the field of forestry its most complex and interesting problems. A brief survey of the scope of this new science will convince us that here is a fruitful field for the investigator, a field full not only of intensely interesting scientific study, but one of immense practical value. As has been pointed out before, not only does forest ecology deal with the relation of the environment to the structure, form, functions, and life processes of the tree, but also to the tree as a whole and to forest formations. This is an immensely broad field for one science to cover. Some of these relations must be worked out in the field, others in the laboratory. The former phase of ecology is almost always recognized, the latter not always; hence before discussing field problems I will say a few words about laboratory problems, which have received very little attention in the past.

The morphological and physiological phases of ecology must to a large extent be worked out in the laboratory. The proper handling of these problems presupposes the use of microscopes, greenhouses, constant temperature rooms, and other laboratory equipment, besides the most painstaking laboratory methods. While field problems seem to be more practical and useful, it must not be overlooked that laboratory problems are more fundamental. Also it is extremely important that these two phases of ecology should be correlated, because in the ultimate analysis of most field work we cannot escape the fact that the effect of the environment upon living trees is mirrored in their form, structure, and behavior, and that it is principally by a laboratory study that trees are able to reveal to us what external conditions are doing to them. The effect of habitat factors upon transpiration, upon the operation of the photosynthetic mechanism, upon the beginning and the termination of root activity, and upon the germination of tree seeds are a few of the physiological problems that need attention. Studies dealing with the formative effect of habitat factors upon the external morphology and the internal anatomy of the tree are important because changes of this nature are usually more obvious than changes in the behavior of the tree. The problem of tolerance will undoubtedly be solved in a scientific manner only after a study has been made of the effect of light upon the minute structure of the leaves of sun and shade plants. The effect of soil moisture upon root and stem development of the seedling and of habitat factors in general upon the structure, composition, and the strength of wood are a few of the morphological problems that might be suggested.

The great importance that has been attached to field problems is undoubtedly due to the fact that foresters are in a better position to work these out than they are the laboratory problems. The growing need for field investigations is due also to certain economic conditions which demand that this class of problems be given immediate attention. There are three important facts or groups of facts which point to the field problems that must engage the forest ecologists' attention in this country at the present and for some time in the future. These facts are: (1) The large number and variety of the species, (2) the diversified conditions of tree growth, and (3) the unproductive condition in which most of our idle absolute forest land is in today. We have in this country from 150 to 200 species which are silviculturally important and between 100 and 125 species which are commercially important. We must work out the silvics of these species ourselves; we cannot depend upon any information from abroad. Our extremely diversified climatic and topographic conditions make silvical problems more complex. Many species have a wide

range, which means a great variation in habitat requirements. Present forest conditions, which are the result of fires, insect ravages, and lumbering, bring before us another set of problems which are of great economic importance. The millions of acres of non-agricultural lands which are lying idle must sooner or later be clothed with timber. This means the investigation of innumerable nursery and planting problems. On account of certain economic conditions the systems of natural reproduction will hold a foremost place in our consideration for many years to come. These require a greater silvical knowledge and a more discriminate use of that knowledge than do the systems of artificial reproduction. In short, American conditions generally are favorable to the development of the science of forest ecology on a scale hitherto unheard of in foreign countries.

In working out these field problems forest ecology can render at least three great services: First, by assisting the forester in studying and measuring habitat factors, and thus increasing the knowledge concerning the requirements of our trees; secondly, in helping him to understand better the successes and failures of both natural and artificial reproduction; and, thirdly, in giving him the ecological point of view in dealing with the origin, development, and succession of forest formations. Besides this the forester will also have use for ecological methods of habitat investigation, as well as the methods and principles employed by the ecologist in attacking other field problems. The forester ought to be acquainted thoroughly with the use of the various instruments used by the ecologist and the methods of taking readings and recording the data. He ought also to be familiar with such terms as stimulus, response, adjustment, and adaptation, and with the ecologist's conceptions of the phenomena of succession, invasion, alternation, and zonation. In fact, the scope and the importance of forest ecology demands that the forest ecologist must not only be a botanist of no mean rank, but particularly a plant ecologist, since the principles and methods of forest ecology are identical with those of plant ecology.

THE INVESTIGATION OF HABITAT FACTORS

The complex of climatic, edaphic, and biotic factors which influence the life, growth, and reproduction of a plant is known as its habitat. As is the case with securing other silvical data here also, there are two general methods in use for studying the relation of the plant to its habitat; these are the observational and the experimental. In the observational method we observe the kind of vegetation produced in response to a certain complex of physical factors and seek to find constant relations of

one to the other in order to draw conclusions. In the experimental method we may either synthetize an artificial environment and proceed to study the plant under definitely measured differences of light and water, or we may measure the physical factors influencing the same plant under various natural environmental complexes. The first one of the experimental methods is, strictly speaking, a laboratory or greenhouse method; the latter is a field method. The observational method is largely a study of the effect produced by habitat factors, while the experimental method is a study of the causes which produced these effects. This is a fundamental difference and it is an important one when we take into consideration the final results secured.

The choice of method in the investigation of habitat factors depends largely upon the nature of the problem. The observational method is very limited in its application and the value of the final results it secures. Because it deals largely with effects, this method is not a safe one, since cause and effect do not always bear a constant relation to each other. The same habitat factors do not always produce the same effects upon vegetation due to some variable factor that is not apparent. The influence of two habitat factors may be the same so far as the structure, behavior, or mere external appearance of the plant is concerned, yet upon inquiry into the causes concerned we may find in one case it was due to low temperature and in the other to a lack of soil moisture. In general, it is true that the observational method is ill-suited for most work in habitat relations, because the habitat involves an extremely variable array of uncontrolled physical factors, and it is practically impossible to determine without measurements which factor has the controlling influence and the relative importance of the others. The only safe method in this kind of work is to measure each single cause, thus employing a perfectly direct scientific method rather than an indirect one which, while it may be scientific, involves uncertainties.

The physical factors of the habitat divide themselves into two classes—the climatic and the edaphic. The climatic factors usually operate over large areas and give rise to major vegetational differentiation into forest regions or zones. The edaphic or soil factors operate over small areas and cause minor differentiation into forest types and subtypes. But the investigation of habitats as entities avails us very little until we analyze a habitat into its component parts and investigate each part. If, for example, we wanted to discover the physical factors which caused the north aspect of a ridge to grow Douglas fir and the south aspect to grow yellow pine, when the two aspects were separated only by a few rods, we would not expect to find the difference due to broad climatic factors, like tem-

perature and precipitation, but rather to soil factors, like soil moisture, texture, and temperature. So in habitat problems of this kind it is usually possible to eliminate at the start one group of factors. If the climatic factors were eliminated, as in this case, the problem would resolve itself into measuring each of the soil factors and determining which factors had the controlling influence in causing the difference in vegetation. From this it is obvious that comparing two or more aspects, even though they are close together, would lead to inaccurate data, because aspects are complex entities, not single factors. If we should wish to discover the causes for the difference between yellow-pine forests in New Mexico and those in California, we would look for this difference among the broad climatic factors rather than among the soil factors.

One of the principal objects of measuring habitat factors is for the purpose of determining the requirements of species. In our country we often find three or four, sometimes as many as eight or ten, species occupying the same site; which of these to favor when marking timber for cutting is largely an ecological problem, inquiring into the requirements of each species and determining which is best adapted for the given conditions. It is not so important to secure absolute figures as it is to know the relative requirements of closely associated species. The systematic determination of habitat factors would lead to the construction of scales of light, soil moisture, and soil texture requirements, which would be more accurate than any scales we have ever used. The scales now in use would either be substantiated or revised to suit the new data.

APPLICATION TO NATURAL AND ARTIFICIAL REPRODUCTION

Silviculture has for its aim the production of the best quality of forests in the greatest quantity, in the shortest time and at the least expense. It is the purpose of silvics to furnish the data so that silviculture can accomplish these aims. This means the investigation of two groups of problems: those concerned with the tree and the forest and those concerned with the habitat. The relation of one group to the other, as has been said before, is one of cause and effect, and the study of one group can furnish us with very little positive information without a consideration of the other. For example, both in natural and artificial reproduction it is important to know not only the requirements of the species with which we are dealing, but also the climatic and edaphic conditions prevailing upon the area. In the case of reforestation we might find indications that the species we were about to plant had been grown successfully in that locality before. Numerous trees of that species from 300 to 500 years old upon or near the area would assure us in most cases that our

plantation would be a success. If for any reason the site conditions on the area had changed materially following the destruction of most of the original forest, we would be confronted with a complex problem of habitat factors before reforestation could proceed. If planting followed immediately upon the clear cutting of the area, with no chance for site conditions to deteriorate, we might expect success on the hypothesis that what has grown there for the last 300 to 500 years will also be very likely to grow there for 100 to 150 years in the future. If for any reason our plantation should be a failure, in nine cases out of ten we would have no positive means of ascertaining the reasons. We might study the effects which certain unknown factors had upon the seedlings and from them guess the causes which produced them; but not only is that a poor method of scientific reasoning, but it very often leads to serious blunders. The solution of the problem lies in the exact determination of the causes involved, namely, the habitat factors. In the case of afforestation, it is even more necessary to study the requirements of the species and of the site, since there are no old trees present to give us a history of the site.

Nursery problems are another large group of problems that require quantitative determinations concerning the physical requirements of tree species. How much light and soil moisture seedlings require at various stages in the nursery is still a problem which has scarcely been started. Obviously nursery problems should be taken up for solution before planting problems, and no commercial planting should be undertaken until at least the principles of nursery and planting practice have been established by careful and extended experimentation in habitat relations.

Theoretically, a forester who expects to establish new forests should know not only how much shade a species will endure, what kind of soil it will require, and what minima of soil moisture and temperature it will endure, but he must know how much light and rainfall the area enjoys, the nature of the soil, its water-holding capacity, and other features. This point is well put by Ganong, a well-known plant physiologist. He says: "Any plant stands where it does for the reason that the physical demands made by the structure and habit it happens to possess overlap in some degree the physical conditions prevailing in that place, and the better they match the more nearly does the plant find its optimum, and the worse they match the more slender is the hold of that plant upon that place." He might have added to this truism, that only the careful determination of the physical demands of the plant and the physical conditions prevailing on the place will settle the question as to how nearly these two match.

Afforestation and reforestation will be put on a firmer foundation as soon as we attempt to explain losses and failures by ecological means and methods. The presence or absence of natural reproduction of a species in a given forest may be explained in a similar way. Also all other phases of silvicultural work which have to do with the reproduction of forests should have as a basis the systematic determination of habitat factors. A good example of this class of problems is the gathering of tree seed. We collect tree seed, perhaps take some notes as to the place where it was collected, and later make tests of its germinability. The germination per cent may be high or low, but in either case we do not tie in our germination results with habitat factors. Can we say conclusively that the best sugar-pine seed comes from that region of the Sierras which enjoys an annual rainfall of from 50 to 60 inches and an average temperature of from 50 to 55 degrees?

THE INVESTIGATION OF FOREST FORMATIONS

A study of the structure and behavior of vegetation is perhaps in no science so important as in the field of forestry. It is as necessary to study forest formations as it is to study the individual tree, and ecological methods are just as helpful in the study of one as in the other.

The ecological study of the vegetative units of a region must necessarily be preceded by a study of the vegetation as a whole. In fact, in studying the vegetation of a particular region plant ecologists have established and followed certain steps. Following a general reconnaissance study, the first procedure is, of course, a systematic study of the flora of the region in question. This is known as floristic ecology, or simply floristics. This is followed by a study of the distribution of the different plants, which naturally leads to the delimitation of vegetative units. The third step is the investigation of the causes of distributional differentiation; in other words, the study of the underlying causes of vegetative units, namely, the habitat factors. It is of the utmost importance that both forest ecologists and plant ecologists follow this method, for only in this way can the results secured in the two fields be harmonized. Here, again, it is obvious that botany is of fundamental importance; for, in addition to being a plant physiologist and morphologist, the forest ecologist must be a systematic botanist.

Following the determination of the vegetative units, it becomes necessary to investigate the structure and behavior of these units. Here, again, the various terms long established by plant geographers and ecologists are of service. The phenomenon of association is a fundamental law of vegetation. Associations of plants may be classified on the basis of the

stratum to which the plant is attached, upon soil moisture, upon light, or upon some other factor. The names of the associations based upon these factors as well as the principles of classification are generally known. Other important phenomena of vegetation are succession, invasion, zonation, and alternation. A study of these is important in any study of vegetation or of vegetative units. They serve to describe the structure and explain the behavior of groups of plants. The classification of vegetative units naturally follows a thorough study of these units. The importance of determining, naming, characterizing, and systematizing the various units of vegetation needs no comment. In the following paragraphs I will briefly speak of the various phases of the subject mentioned above.

There are many ways in which the study of the structure and development of vegetative units can be applied. The investigation of forest associations and forest formations should aim to distinguish them on the basis of some important physical factor. As certain ecologists have found, differences in composition of forests may be due to differences in the rate of evaporation, to the size of soil particles, or to distance to the water table. It is important, also, to classify our associations, to elevate the important ones, and to subordinate the less important. Invasion is a phenomenon which is closely connected with the natural reproduction of forests. A study of the laws of invasion and of the methods of attacking problems to determine the rapidity of invasion of tree species is necessary to the proper understanding of the development of forests. The relative rapidity of invasion of tree species upon bare areas, burned or cut-over lands is best determined by the use of the quadrat of the ecologist.

Succession is likewise intimately connected with the reproduction of our forests. It is of great value to know what stages a forest which has been burned over or cut must pass through before it can revert to its original or climax form. It is important to know what physical factors determine succession in old burns, barrens, brush areas, and logged areas. Succession has been shown to be due in some cases to variations in the moisture content of the soil. The problem of reforesting chaparral areas in California may possibly be capable of solution by a minute study of brush-plant succession and the measurement of the physical factors governing the presence of each species or group of species. It has long been known that the climate inside of the forest is different from that outside; but it was not until very recently, in studying succession under planted groves on the prairies, that Pool showed that the planting of timber changed conditions underneath the stand so completely that the xerophytic grassland association gave way to a mesophytic forest association.

The need for a better phytogeographical classification of our forests has long been felt, and in this case, also, the forester would do well to follow the scheme now in use almost universally by ecologists. While it is immaterial what names we give to vegetative units, it is important to use a rational basis for their classification and identification. The terms plant formation and plant association have been used with various meanings for almost a century, but today the conception that a formation is an ecological genus and an association an ecological species is becoming generally accepted in principle. The broadest unit of vegetation is called a phytogeographic region. Regions are divided into plant formations (which correspond to forest types) and the latter into plant associations (subtypes), societies, communities, and families. The order of classification cannot be changed at will, since the fundamental idea is the same as in systematic botany, where order, family, genus, and species represent groups of decreasing size and importance. The abundance of species, or of individuals of the same species, is the most conspicuous character of vegetation and is used as a primary basis for the classification of vegetative units. But in naming a unit it is sometimes desirable to take into account the character of the habitat. Therefore formations and associations are often classified by some striking physical or physiographical character of the habitat or by some dominant vegetational characteristic. The aim in the classification is simplicity, accuracy, and a uniform classification of all units on the basis of abundance. The abundance of species or of individuals of the same species is usually the distinguishing character of the plant formation and each successive smaller unit of which it is made up. The vegetational difference, therefore, which distinguishes one unit from the other is simply one of degree, not of kind.

The classification of our forests is in a chaotic condition. One set of principles is applied to our Atlantic forests and a different method is employed in classifying the Pacific and Rocky Mountain forests. The unit of vegetation which we call a forest region in the East is known by the name of a forest type in the West. It is generally not recognized that the climatic zones met with in the East in the form of broad belts traversing the continent in an easterly and westerly direction from the Gulf to timber-line in northern Canada are measurably similar to the climatic zones met with on the coast in the form of successive altitudinal zones, each one higher than the one before. Thus if in the former case we recognize the southern pinery, hardwood, Lake States pinery, and northern spruce regions, why not in the latter case recognize the foothills, yellow pine, sugar pine, red fir, and subalpine regions, which are now known as forest types? And, to carry the comparison still further, if we recognize

in the Lake States forests the white pine, red pine, jack pine, and hardwood types, why not recognize in the sugar-pine region on the coast the sugar pine-yellow pine, sugar pine, sugar-pine fir, fir, and lodgepole-pine types, which are now called subtypes? It will be seen that those formations in the West which we call types are in their very nature extremely complex and cover widely different habitats, and for this reason should be considered analogous to the forest regions recognized in the East. Ecology can render forestry no greater service than to help solve this problem in a sound and logical manner, and this can only be done by a systematic study of the forests themselves and the physical factors which determine them.

THE NATURE, SCOPE, AND RESULTS OF SILVICAL INVESTIGATIONS

The results of study and investigation in this field depend upon many factors which the average student of scientific research already knows; hence I will not dwell on these, but point out some characteristic or, perhaps, peculiar features concerning this field of work. The practical value of silvical problems is such that it might be worth while to emphasize certain fundamental concepts. There are at least three principles which must be recognized when estimating the value of silvical work; these are: First, that many of these problems strike at the very foundations of national prosperity, and their value cannot be measured in dollars and cents; second, many of these investigations form the basis for the silvicultural management of the future, and their value must be gauged by future returns rather than present; and, lastly, it is the avowed purpose of scientific work to attempt to solve those problems in which the so-called practical worker has failed to produce results. These three statements constitute, if it is necessary to give it, silvics' "raison d'etre."

Some silvical problems are of value because something definite has been gained; others because some great economic loss has been prevented. The value of most problems lies in the future; only comparatively few will yield present returns, and then not in a direct monetary way but an indirect one. It is comparatively easy to estimate the value of a piece of work when it is possible to base that value upon what has been actually gained, but how hopeless is the task when we must base our estimate upon the loss which that piece of work prevented. For example, in gauging the value of such silvical investigations as the influence of forests upon stream-flow, or the water supply of our people, which problems are vital to the health and prosperity of all, we are unable to arrive at a dollars and cents estimate, yet we soon realize after a little reflection that, compared to the loss prevented, the cost of working out these problems would fade into insignificance.

Silvical investigations as well as forestry business are long-time propositions. The value of such work is very often measured not so much by the immediate financial returns it brings as by the principles it helps to establish, which in turn affect our silvicultural management or our forest policy many years hence. What the future returns will be can only be conjectured; at any rate they will be out of all proportion to the present cost of securing the data.

We may take as axiomatic the statement that the future of silviculture depends for its success upon the proper application of the science of forest ecology. The empiricism of the past will give way to the science of the present and of the future; the methods of the past will not be the methods of the future. In European practice this change has already taken place; in America it is about to be made. Modern European silviculture is based upon centuries of empiricism; only within the last 50 years has it begun to be based upon scientific experiments. Practically all of American silviculture dates back only 25 years; scientific silviculture has scarcely begun, because experimental silvics is not much more than five years old. As a result American silviculture, much more than European, is burdened with undigested facts which the American practitioner has accumulated for more than a score of years. By explaining these facts the new science of American silvics will gain immediate recognition and make scientific silviculture possible—a thing which years of blind groping along applied lines has failed to accomplish. The motto which silviculture could safely follow is: "Science with practice" rather than *vice versa.* We must study and experiment before we practice, for only such a method of procedure will obviate costly, time-consuming, and aimless silvicultural practice.

As a corollary to the statement that American silviculture will depend upon the science of forest ecology, we must appreciate the fact that this science will be based upon original research. The chief value of European experience has been not so much in the facts it has taught us about European tree species as in the methods used to secure those facts. What we have learned from this source has proven invaluable, but we will need much more than this in the future. It must be realized that a rational American silvicultural system must be based on original silvical research under conditions which the American forester is confronted with. The problem is a gigantic one, but American foresters are equal to it. We have developed logging methods which are unique in forest industry: we are establishing a system of fire protection unlike anything yet attempted by forestry-practicing nations; it still remains for American ingenuity and enterprise to solve the many silvical problems that confront the American forester.

The field of forest ecology, with its many correlated problems and groups of problems, may be likened to a vast ganglionic network. Very few problems are complete in themselves; usually each one is closely related to many others. Each group of related problems is one big problem in itself, and only the orderly and systematic solution of each problem in the group will lead to definite results. There has been a tendency to dabble in a dozen or more widely different problems at once instead of confining the attention to one or a few. Also much work has been done without a careful study and summary of what has been done by others in that particular field. It is important to search not only the field of forestry, but also related fields like botany and agriculture. For example, if the problem is on the effect of size of tree seed upon the germination per cent, the investigator ought to look up all work done with garden and agricultural seeds as well as tree seeds in order to make his work more comprehensive and complete. The chances for errors in judgment like these are many, and will undoubtedly continue to be until the science has been worked up to a sound basis.

It is desirous in such a tremendously large field of work to get the important, general principles established first in order to have a well-constructed foundation to build upon in the future. In erecting the superstructure it will require a judicious use of scientific perspective in order to give due relative prominence to the important subdivisions of the science to determine what should be omitted for the present and to ferret out those things first which we will need most. With this in mind, there is appended to this paper a synoptical outline of the problems of forest ecology, or silvics, in which the attempt is made to outline the whole field and to give the great groups into which the field naturally divides itself.

The direct results of silvical study have been discussed more or less throughout the whole paper; I have yet to mention a few of the indirect results of the work which I think should not be overlooked. Not all the benefit derived from such investigations will be in the form of figures and curves. A real and lasting result will be the ideas and conceptions formed by the investigator when tying in and comparing his figures with conditions as they exist in the field. He will form a rather definite conception of what a moist habitat looks like and ought to be able, by only superficial examination, to guess with more accuracy than he ever did before what the moisture per cent of a given soil is. He ought to get definite ideas as to what various light intensities look like and he ought to form similar more or less definite notions about other habitat factors, all of which will be of great use to him when he is away from his instruments. In short, his actual field determinations will give him measuring

sticks, by which he can judge with considerable more accuracy than he ever did before what degree of a certain factor is present in a given habitat.

In helping the forester to work out the problems already indicated, plant ecology doubtless will have a great influence upon the philosophy of forestry, and especially upon silviculture. Plant ecology has had a most wholesome influence upon plant physiology, in that it has changed it from a laboratory-ridden science to the experimental study of "out-of-doors" plant life. In a similar manner ecology will, for a time at least, detract our attention from "what the books say" to "what the psychrometer or the thermograph says" about the woods. In other words, qualifying adjectives will give way to quantitative data. Generalities and platitudes will give way to scientific experimentation on a plane with that which is performed in other experimental sciences. Up to the present time, as far as silviculture is concerned, too much emphasis has been placed upon general field observations and conclusions and not enough upon the exact determination of facts. It matters very little whether the practice of forestry be extensive or intensive in nature; by private corporations or public; in the East or in the West; the fact remains that we need to know more about the very essence of forestry, about the living, growing organisms in our woods—the trees and the forests.

CLASSIFICATION AND SUMMARY OF THE PROBLEMS OF FOREST ECOLOGY

The following synopsis is the attempt to give in outline form a glance over the whole field of forest ecology. It is by no means a settled matter what should be included in this field; as a matter of fact there have been very few attempts to define or delimit the science. The synopsis here presented is made as broad and general as possible, so as to include under various major headings all the larger phases of the science which it seems fitting and proper the subject should embrace. Each topic in the outline is capable of division into many subtopics, and of course the latter also are divisible. No attempt has been made to arrange the six groups of problems in the order in which they should be taken up, because under some conditions they would be taken up in the order named and under others in the reverse order. In one sense it seems more logical to study the tree before considering the forest; but the history of ecology and plant geography teaches us that the study of floristics precedes the study of vegetation, and that the study of distribution and of vegetative units precedes the study of habitat factors. In other words, experience teaches us to study the general features of vegetation before we take up the details.

As I understand the subject of forest ecology, it embraces six great groups of problems, as follows:

Problem I.—*The abstract investigation of habitat factors in all their ramifications* and their determination by means of instruments preferably autographic.

Problem II.—*The relation of the structure of the tree to external conditions.* This is essentially morphological ecology. It includes both organographic ecology and ecological anatomy; in other words, it deals with the influence of the physical factors of the habitat as mirrored in the internal and external structure of the plant or tree.

Problem III.—*The relation of the behavior of the tree to external conditions.* This is essentially physiological ecology. The various functions and life processes of a tree must be studied in connection with external factors. This will lead to a complete physiological life history of each tree species. We must devise methods and instruments, for the most part autographic, for measuring and recording each physiological process. We must, furthermore, develop a standard system of measurements for each physiological process.

Problem IV.—*The relation of the tree as a whole to external conditions.* This is the problem of silvics as it is ordinarily known to foresters. It is, of course, intimately related to both morphological and physiological ecology. Being a summary of the occurrence, habits, and requirements of each tree species, it actually sums up in the case of each species the problems involved under II and III.

Problem V.—*The relation of the structure and behavior of the forest to external conditions.* The study of the individual tree is followed by the study of tree associations and formations. The former study is termed autecology, the latter sinecology. This problem is essentially physiographic ecology, or the ecology of vegetation.

Problem VI.—*The influence of the forest upon external conditions.* This is the problem of forest influences, which while ecological in nature is probably more intimately related to forest policy than to silviculture.

Problem I is both a field and laboratory problem, though more essentially the former; II and III are distinctly laboratory problems, while IV, V, and VI are distinctly field problems, though much of IV, as has been pointed out, depends upon what has been worked out in II and III. Problem I constitutes the so-called ABC's of the whole science of forest

ecology; problems II and III are, so to speak, the connecting links between I and V and VI.

I.—*The physical factors of the habitat.*
- *a.* Edaphic.
- *b.* Climatic.
- *c.* Biotic.
- *d.* Historic (geological).

II.—*The influence of the physical factors upon the structure of the tree.*
- *a.* Roots.
- *b.* Stem.
- *c.* Leaves.
- *d.* Reproductive organs.

III.—*The influence of the physical factors upon the life processes of the tree.*
- *a.* Diffusion and osmosis.
- *b.* Transpiration.
- *c.* Photosynthesis, translocation, digestion.
- *d.* Respiration.
- *e.* Growth and movement.

IV.—*The influence of the physical factors upon the tree as a whole.*
- *a.* Occurrence.
    - Local.
    - Geographical.
    - Commercial.
- *b.* Associated species.
- *c.* Habit of tree (height, diameter, bole, taper, crown, leaf-fall, root system, bark, age, growth rate, resistance, etc.).
- *d.* Requirements of soil and climate for
    - Germination of seed.
    - Seedling life.
    - Adult life.
- *e.* Reproduction (age of seed-bearing, seed years, dissemination, vitality, and germination per cent of seed, etc.).

V.—*The influence of the physical factors upon the forest.*
- *a.* Upon forests in general.
    - Distribution.
    - Composition.
    - Character and density.
    - Growth.
    - Reproduction.

V.—*The influence of the physical factors upon the forest*—Continued.

- *b.* Upon forest formations.
  - Classification of forest formations.
    - Kinds of formations.
    - Factors determining.
    - Identification of formations.
    - Naming.
  - The structure and behavior of forest formations.
    - Association.
    - Invasion.
    - Succession.
    - Alternation and zonation.
- *c.* Upon trees in the forest.
  - Classification of individual trees.
  - Classification of tree species.
  - The structure and behavior of trees in the forest (see under IV).

VI.—*The influence of the forest upon physical factors.*

- *a.* Upon climatic factors.
- *b.* Upon edaphic factors.
- *c.* Upon stream-flow.
- *d.* Upon water supply, health, agriculture, etc., etc.

FIVE YEARS' GROWTH ON DOUGLAS FIR SAMPLE PLOTS

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Five years ago the Forest Service began the establishment of permanent sample plots in the second growth Douglas-fir forests of the Pacific Northwest. The purpose of establishing these plots was to secure by periodic remeasurements a record of the life history of the stand and of the actual growth that was taking place.

The first three plots established came up for remeasurement this past spring. Even in this short interval the measured growth is large enough to be striking. These plots are located in the midst of an extensive stand, now 59 years old, of almost pure Douglas fir, on a rolling north slope on the foothills of the Cascade Range within the Cascade National Forest. When the plots were established in 1910 each individual tree was numbered with a galvanized iron tag, and its crown class and diameter (secured either with diameter tape or with averaged caliper measurements) recorded; for a few of the trees their height was also taken. In 1915 the plots were remeasured; the field work was done by the same person, the author, and identically the same field methods were used. The volume of each individual tree was then worked up, using the same volume tables in each instance, so that no inconsistency might enter into the calculations of growth. For the trees 12 inches and over in diameter the board-foot contents were calculated, assuming an utilization to 8 inches in the tops. For the trees of all sizes down to 4 inches in diameter the cubic-foot contents of the entire stem were calculated.

This is undoubtedly the first occasion upon which an actual record of the growth of a Douglas-fir forest in the Pacific coast region has been secured. It shows the very high annual increment of 188 cubic feet, or 1,259 board feet, per acre for this stand from its fifty-fourth to its fifty-ninth year. This is a record which has perhaps not been excelled by any natural stand of coniferous trees the world over, where measurements were made on the same basis of utilization.

The growth that has taken place on these plots is shown concisely in the following table:

	Plot I.	Plot II.	Plot III.	Average of all plots.
Number of living Douglas firs:				
In 1910	188	214	186	196
In 1915	175	198	172	182
Volume of living Douglas firs over 4 inches d. b. h.—gross scale in cubic feet:				
In 1910	7,934	9,399	9,277	8,870
In 1915	8,749	10,316	10,372	9,812
Average annual growth per acre in cubic feet	163	183	219	188
Volume of living Douglas firs over 12 inches d. b. h.—gross scale in board feet:				
In 1910	33,040	39,448	39,897	37,462
In 1915	38,656	45,404	47,213	43,758
Average annual growth per acre in board feet	1,123	1,191	1,463	1,259

The actual measured growth rate on these plots is almost identical with that indicated by the study made in 1909 of comparative stands of various ages on Quality I soils in this same region, the results of which were published in Forest Service Circular 175. This study indicates an annual rate of growth of 210 cubic feet, or 1,300 board feet, for a 60-year-old forest.

The stand as measured this year at 59 years of age contains (gross scale) 43,758 feet board measure, or 9,812 cubic feet, while the table in Circular 175 shows an average yield for stands of this type at 60 years of 41,000 feet board measure and 9,650 cubic feet. It should be understood that these figures are for the gross contents of the trees, no allowance being made for defects or for wastage in logging. These figures would corroborate the off-hand judgment, made several years ago, that this was a very representative average stand of good quality Douglas fir second growth for the Oregon Cascade foothill region.

Using the formula adopted by Mr. E. J. Hanzlik, after Medwiedew, for determining site quality $\frac{(F = \textit{Av. ht. x total basal area})}{\text{Age}}$, we find that these plots now have a factor of 432. Mr. Hanzlik[1] found that in the west of the Cascades region Quality I sites had a factor of 471, Quality II 348, and Quality III 251; the very best sites had a factor considerably above 500. For each plot for both the years 1910 and 1915 the factors were as follows:

[1] A Study of the Growth and Yield of Douglas Fir on Various Soil Qualities in Western Washington and Oregon, by E. J. Hanzlik, March 14, 1912.

	In 1910.	In 1915.
Plot I	326	362
Plot II	449	487
Plot III	402	454
Average of all plots	392	432

This indicates that this tract would rank as a low Quality I site, in a classification where three qualities are distinguished.

Analyzing the full statistics of these plots, some of the more interesting facts are as follows:

1. The average stand of Douglas fir per acre was 37,461 feet board measure, or 8,870 cubic feet, in 1910. Now it is 43,757 board feet, or 9,812 cubic feet. This represents a gross increment of 6,296 board feet, or 942 cubic feet, in the five years. Added to this is 107 cubic feet of dead Douglas fir, which is, of course, a part of the actual potential yield.

2. The average number of living Douglas fir in 1910 was 196 to the acre; now it is 182, of which 113 are 12 inches or over in diameter.

3. Illustrating the changing proportion of each class of trees, the number of dominant trees has decreased by about 35 per cent, the number of intermediate trees is less by about 10 per cent, and the number of suppressed trees is larger by about 40 per cent. In short, a small percentage is dying each year; quite a large percentage is passing into the suppressed stage, and fewer trees are remaining dominant.

4. A few trees have grown in diameter over two inches, but the increment of most of them is a little less than one inch. The height growth is about 15 feet for the period.

These three plots are to be examined again in 1920, and thereafter every five or ten years. Plots have been established in other Douglas fir second growth stands, some of which are on even more productive sites, and are expected to record, when they come up for remeasurement, even more rapid growth than these for the Cascade National Forest.

LIGHT BURNING AT CASTLE ROCK

BY S. B. SHOW

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During the past three years data have been secured on the Shasta National Forest, in northern California, which show beyond question that the "light-burning" theory is absolutely untenable when the establishment of new reproduction or the preservation of existing reproduction is desired. While this fact is generally recognized by foresters, the advocates of light burning have refused to admit it. The further contention of foresters that light burning does not protect is also in direct opposition to the belief of the light burners.

In order to secure reliable data on these points, experiments were started in the spring of 1911 on a suitable area, and observations have been continued during the past three seasons.

On March 20, 1911, an area of about eight acres was burned over at Castle Rock, California, under conditions that were very favorable for a trial of light burning. The area varies from 2,100 to 2,300 feet in elevation, has a south or southeast exposure, and the slopes range from gentle to moderate (10 to 35 per cent). The timber consists of yellow pine, with a slight admixture of sugar pine, Douglas fir, incense cedar, and California black oak; the stand averages 6,000 per acre.

The most important factor, next to moisture, affecting the severity of fire was the amount of inflammable material on the ground. The litter, consisting for the most part of pine needles, and to a lesser extent of leaves from the oaks and underbrush, varied greatly in depth, from a mere sprinkling of needles on the more exposed portions of the area to a layer 1 inch in depth in the denser thickets of saplings. Since the area is grazed, there was no grass or weeds to add fuel.

The underbrush consisted of low scattered bushes of *Ceanothus* sp., locally called "buck brush," which were rarely over 2 feet in height, with occasional clumps of oak brush and manzanita. In the sheltered spots the brush covered about half of the ground, but over the area as a whole only a quarter to a third of the ground. A casual examination immediately after the fire seemed to show that comparatively little damage had been done to reproduction, and that the inflammable material on the

ground had been very completely consumed, so that in this particular case the fire had apparently fulfilled the object of light burning without causing much damage to the young stuff on the ground.

The conditions on the burned area were optimum for light burning. Heavy rains had fallen less than two weeks before the date of the fire, but warm weather had dried out the ground cover and litter to an extent which allowed fire to spread. Had there been any greater amount of moisture on the ground than there was, the fire very probably could not have spread. Moisture conditions could not have been better to reduce to a minimum the amount of damage to reproduction.

The fire started from a burning brush pile, and ran uphill. No effort was made to stop the fire, and it spread slowly, since there was little or no wind to fan it. Where the litter was thinnest the fire was so light that the litter burned only around the clumps of brush, and it was evident that the fire had spread by jumping from one clump of brush to the next. In such cases only the leaves and smaller twigs had been burned from the brush; but where the litter was deeper or steeper slopes developed a stronger draught, the brush was occasionally consumed to the ground. Only the surface of the litter was dry, so that for the most part a considerable portion of the deep layers of needles was unburned, or at most merely charred. Brush was the chief source of inflammable material, and the hottest fire developed in it. For the most part, fire only skimmed over the surface of the litter.

It is evident, then, that this fire was about the lightest which could have burned, and that conditions were most favorable for keeping damage to the minimum.

The reproduction was plentiful, though unevenly distributed. In the shallow gulches and in the cooler, moister sites, dense thickets of seedlings and saplings of yellow pine and incense cedar occurred, while on the more exposed points the young growth consisted of scattered yellow pines. Between these two extremes all gradations occurred, and in general the amount of reproduction present on any particular area indicated the quality of that site. This is true, since the area had been undisturbed by fire for 14 years, so that there had been ample opportunity for reproduction to come in. The following plots show the amounts of reproduction under different conditions:

TABLE 1—*Open stand of seedlings. Area represented, 1/10 acre*

Species.	Seedlings.
Yellow pine	44
Incense cedar	106

TABLE 2—*Full stand of seedlings and saplings. Area represented, 1/10 acre*

Species.	Seedlings.	Saplings.	Poles.	Total.
Yellow pine.................	156	241	2	399
Douglas fir.................	2	2	0	4
Incense cedar...............	21	19	2	42
Total.................	179	262	4	445

For the present, reproduction is considered only in its relation to the severity of the fire. The extreme lightness of the fire may be judged by the fact that in one very dense thicket of saplings, where the litter was an inch deep and the leaves of trees reached to within 2 feet of the ground in places, the fire had in no case burned in the crowns of the young trees. In another similar stand located in a steep gully the fire had stripped a few trees of leaves, but had not developed into a real crown fire.

Many seedings up to 3 feet high had been partially consumed, but at least as many more had furnished no fuel. Where small seedlings stood in litter over ½ inch deep the leaves were usually burned, but others standing among scattering litter were killed by the heat rather than by being consumed.

Under less favorable moisure conditions very nearly all of the reproduction on this burn would certainly have been consumed by the flames, and the fact that a very large number were not even blackened is evidence of the low severity of the fire.

In order to determine the extent of the damage to reproduction, three sample plots were laid out, one each in open, fully stocked, and dense stands of seedlings and saplings. On the first two plots the reproduction was counted after the fire and classed as live, doubtful, and dead, keeping the seedings and saplings separated by species in the tally. Since it was evident that the full extent of the damage did not show immediately after the fire, three later counts were made to follow the history of the plots.

For the same reason a number of the larger saplings and small poles which had been injured were tagged, and detailed notes regarding degree of injury, health, and rate of recovery were made at all four examinations.

In order to determine the ages of the oldest seedings and saplings killed by the fire, a considerable number were cut down the fall after the fire. This was done at that time, so that there could be no question that the trees were actually dead and that the fire alone had been responsible for their death. Immediately after the fire it was impossible to tell whether many of the trees would live or not, and it was therefore thought best to eliminate all question as to the condition of the trees cut.

At each examination measurements were made of the rate of growth of the sprouts from clumps of brush which had been killed by the fire. Measurements of the amount of litter which had accumulated under various conditions, both on the burned and adjoining areas, were also taken. These figures make possible a definite statement regarding the degree of protection secured by the fire and the final effects of the fire from the viewpoint of protection alone.

The inflammable material on this area was of the following classes: litter from conifers, litter from brush, brush, and reproduction. The fire had certain immediate effects on the amount of inflammable stuff on the area. The litter, both from conifers and from the brush, was entirely consumed where less than ½ inch thick, but only partly burned where heavier. The brush itself was killed, and part of it consumed. At least as much more retained the dead leaves. A good many of the smaller seedlings were consumed; but many were not, and practically all of the large seedlings, saplings, and poles whose crowns were partially or entirely killed retained the dead needles.

Immediately after the fire, therefore, the amount of inflammable material on the ground was greatly reduced, and it probably would have been impossible for a fire to run over the same area again.

But within six months the conditions had changed very radically. In October of the same year in which the fire occurred it was found that the amount of litter on the ground was equal to that on adjoining unburned areas. This was due to the falling of dead needles from reproduction killed or partially killed by the fire. The brush had put up new sprouts from 10 to 20 inches in height. The fire danger, considering the amount of burnable stuff on the ground as an index, was as great as before the fire.

In August, 1912, a year and a half after the fire, the litter was especially heavy under the dense pole and sapling stands, and the sprouts from the brush were from 2 to 3 feet high. From the fact that about half of the needles were still on the dead trees, it was evident that the fire danger had not reached its maximum.

In September, 1913, most of the dead needles had fallen, with the result that the amount of stuff on the ground was actually 50 per cent greater than on adjoining unburned areas, and in fact was greater than on this area before the fire. A further source of dead material was also beginning to show, viz., the bark and twigs from dead trees.

These facts were determined by measurements of the inflammable material on the burned and adjoining unburned areas made at each examination.

It is therefore evident that as a protective measure light burning was in this case a failure. It did reduce the fire danger for part of one fire season, but the increase of the danger after that period more than offset the temporary advantage.

The worst phase of the theory, from the protection standpoint, is that an actual increase in the fire danger is inherent in the method itself. It is impossible to consume the inflammable material on the ground without at the same time creating a new and larger source of such material in the shape of needles and leaves from young trees killed by the same fire which cleans the ground.

From the standpoint of silviculture the effects of this light fire were little short of disastrous. Over the areas as a whole practically every individual seedling and small sapling of all species was killed; in other words, reproduction up to 15 years old, or 2 inches in diameter, was almost annihilated. In addition, 60 per cent of the reproduction from 15 to 25 years old was killed. This destructive action of the fire is shown more clearly in the following tables:

TABLE 3—*Open stand of seedlings, 1,500 to the acre*

Species.	April 8, 1911.			October 23, 1911.		August 6, 1912.		September 19, 1913.	
	Live.	Dead.	Doubtful.	Live.	Dead.	Live.	Dead.	Live.	Dead.
Yellow pine	6	20	2	3	25	3	25	3	25
Per cent	21.5	71.5	7.0	10.7	89.3	10.7	89.3	10.7	89.3
Incense cedar	8	43	12	19	44	5	58	3	60
Per cent	12.8	68.2	19.0	30.0	70.0	8.0	92.0	4.8	95.2

TABLE 4—*Full stand of seedlings, saplings, and small poles, 4,450 per acre*

Class.	Species.	Dates of examinations.								
		April 18, 1911.			October 23, 1911.		August 6, 1912.		September 19, 1913.	
		Live.	Dead.	Doubtful.	Live.	Dead.	Live.	Dead.	Live.	Dead.
Seedlings	Yellow pine	1	154	1	2	154	2	154	2	154
	Per cent	.6	98.7	.7	1.3	98.7	1.3	98.7	1.3	98.7
Saplings	Yellow pine	6	225	10	14	227	11	230	11	230
	Per cent	2.5	93.4	4.1	5.8	94.2	4.6	95.4	4.6	95.4
Poles	Yellow pine	1	0	1	1	1	1	1	1	1
	Per cent	50	0	50	50	50	50	50	50	50
Seedlings	Incense cedar	0	20	1	1	20	1	20	1	20
	Per cent	0	95.3	4.7	4.7	95.3	4.7	95.3	4.7	95.3
Saplings	Incense cedar	2	14	3	1	18	1	18	1	18
	Per cent	10.9	73.7	15.4	5.5	94.5	5.5	94.5	5.5	94.5
Poles	Incense cedar	1	0	1	1	1	1	1	1	1
	Per cent	50	0	50	50	50	50	50	50	50
Seedlings	Douglas fir	0	2	0	......	......	......	......	......	......
	Per cent	......	100	......	......	......	......	......	......	......
Saplings	Douglas fir	0	2	0	......	......	......	......	......	......
	Per cent	......	100	......	......	......	......	......	......	......

TABLE 5—*Dense stand of seedlings, saplings, and small poles*

D. B. H.	Yellow pine, October 22, 1911. Alive. No.	Per cent.	Dead. No.	Per cent.	Incense cedar, September 19, 1913. Alive. No.	Pe cent.	Dead. No.	Per cent.
2....	15	19.5	62	80.5	6	30.0	14	70.0
3....	14	31.1	31	68.9	5	45.5	6	54.5
4....	12	91.6	5	29.4	6	54.5	5	45.5
5....	6	75.0	2	25.0	4	57.2	3	42.8
6....	3	100.0	0	0	3	75.0	1	25.0
7....	1	100.0	0	0	1	100.0	....	0
8....	1	100.0	0	0	....	0	1	100.0
9....	....	......	....	......	1	50.0	1	50.0
10....	....	......	....	......	1	50.0	1	50.0
11....	....	......	....	......	....	......	....	......
12....	....	......	....	......	2	100.0	....	......

All under 2 inches dead, except two incense cedars 1 inch and 1½ inches.

Stump analyses made the fall after the fire show that a diameter breast high of 2 inches indicates an average age of 15 years, and 5 inches an age of 25 years. It is therefore evident that it will take at least fifteen years before reproduction is as plentiful on this area as before the fire. This statement assumes that seedlings became established immediately after the fire, which as a matter of fact did not occur. Allowing five years for reproduction to come in, the future crop of timber which was represented by the reproduction is put back twenty years.

The statement made by advocates of light burning, that the resulting damage is not excessive, is doubtless due to the fact that the full extent of damage is not apparent for at least six months after the fire. This is shown very decisively by a study of the three preceding tables. Among seedlings and small saplings especially, individuals which immediately after the fire were apparently alive or which looked to have an even chance to survive, later succumbed.

Among large saplings and poles, on the other hand, certain individuals which appeared to be dead or dying immediately after the fire, later recuperated and became healthy. Out of eighteen yellow pine and incense cedar from 3 to 10 inches d. b. h., which were tagged, four trees which appeared dead at first did recover, and all the trees which were classed as living did become healthy in a surprisingly short period.

These observations simply emphasize the fact that it is impossible to determine accurately the extent of damage immediately after a fire; at least one growing season must pass before the true condition can be told.

The study as a whole permits two major deductions:

1. As a protective measure, light burning is a failure for reasons which are inseparable from the method itself.

2. The damage to reproduction is so great that the practice of the system is precluded where the establishment of young growth is desired.

UNIFORMITY IN THE FOREST-FIRE LEGISLATION AFFECTING RAILROAD OPERATION AND LUMBERING

BY PHILIP T. COOLIDGE

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At a conference in New Haven, January 13, 1915, the forestry officials of the northeastern States which receive Federal aid in fire protection under the Weeks law, inaugurated a comparative study of the forest-fire legislation which imposes restrictions relative to railroad operation and to lumbering. It is obvious that serious confusion and inconvenience are occasioned to the railroads and to the State officials by the fact that locomotives on many runs pass through the woodlands of two or even three States, each prescribing a different set of safeguards, or no safeguards whatsoever, to prevent the occurrence and spread of fires. Hardship is occasioned, also, upon competing lumbermen by differences in the laws relative to the disposal of slash after logging. The purpose of the study was to secure general information relative to the need of more uniform legislation upon those phases of forest-fire protection which affect interstate railroad operations or commercial relations. The work consisted in a compilation of comments by the State forestry officials upon the efficiency of the legislation in their respective States, with a digest of the legislation by the present writer. The legislation of the following thirteen States was considered: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, and Kentucky. The apparently arbitrary selection of States was due to the endeavor to include in a relatively compact group those northeastern States which receive the Federal aid referred to, as well as certain other States of importance to the group because of geographical location.

The object of the present article is to describe the legislation briefly, with special reference to certain characteristics which render it effective or otherwise. The complete lack of legislation in some States, of course, is a more potent reason for inadequate fire protection than the mediocrity of legislation in others. It is believed that although each State is best able to determine for itself the particular legislation proper to its needs, some co-operation in the framing of legislation would prove of mutual advantage.

RAILROAD OPERATION

Liability for Damages by Fire

It is clear that uniformity in the requirements pertaining to railroad operation must depend upon the degree of uniformity to which the railroads are held liable for damages and for the cost of extinguishing the fires caused by them. There would seem to be little opportunity for agreement, for example, between a State in which public sentiment has strongly supported measures which safeguard forest property, and has perhaps even connived at occasional injustice towards the railroads, and a State which has given no protection to forest property, and has followed the beck and call of corporation attorneys. That decided differences in policies, as well as in the details of legislation, exist among the States, and frequently for petty reasons, is common knowledge, and is deplored generally. The railroads cannot be blamed for adopting policies which vary accordingly. Where public sentiment is alive to the necessity of fire protection as a prerequisite to the continued enjoyment of forest resources, the railroads have begun to recognize the economy of fire-preventive methods as a means of avoiding expensive damage suits. In northern New England, for instance, where high stumpage values prevail, and where the forests are very susceptible to injury by fire, the railroads have given notable co-operation to State officials in fire prevention and suppression.

Of the States whose legislation was studied, the statutes of Maine, New Hampshire, and Massachusetts place responsibility for damages by fire communicated by locomotives unreservedly upon the railroads, the Massachusetts law reading:

"Every railroad corporation shall be liable in damages to a person or corporation whose buildings or property may be injured by fire communicated by its locomotive engines."

In very few cases do the railroads in these three States undertake to escape responsibility for fires which occur next to their tracks.

The statutes of New York previous to 1909 had placed responsibility on persons generally who suffered fire on their own lands to extend therefrom, but an enactment of that year placed responsibility on the railroads specifically for damages caused by fires originating on the right of way; the law now, as amended, imposes penalty for violation at $10, and damages at $1, for each tree three inches or more in diameter breast high killed or destroyed. The law imposes the same penalties and responsibility upon land owners who use fire in removing brush or who use or man-

ufacture inflammable materials. Bills imposing responsibility similar to that imposed by these provisions of the New York law have been introduced in recent Pennsylvania sessions, but have failed to pass.

Connecticut places responsibility for damages by fire upon the railroads except where there has been contributory negligence on the part of those responsible for the care of the property injured. Vermont, New Jersey, Pennsylvania, Maryland, Delaware, and Kentucky place greater or less responsibility upon the railroads for damages which have resulted from violation of various statutory requirements designed to prevent the occurrence and spread of fires. The Connecticut statute allows insufficient time, only 20 days, for the submission of claims. The New Jersey statute allows one year, but the statutes of none of the other States mentioned limit the time during which claims may be presented to the railroads. A very old Pennsylvania statute (Act of April 18, 1794) which places responsibility on persons who set the woods on fire for any purpose, has been held to be operative respecting fires caused by railroads, but is probably superseded now by Act 353, Laws of 1915, which makes parties responsible for the operation of any property liable for damages caused by fires occasioned by such operation.

Since the common law imposes liability for damages generally upon any one guilty of negligence, the railroads in Rhode Island and West Virginia, notwithstanding lack of specific statutes in these States, are liable for damages caused by fires due to their negligence. This liability under the common law is strengthened in West Virginia by the fact that there is a statute requiring the use of protective devices and clearing of the right of way.

The question whether or not the position taken by the Maine, New Hampshire, and Massachusetts statutes, in placing full responsibility upon the railroads for damages caused by fires is fundamentally just, does not seem worth consideration, since the railroads are now subject to regulation by State and Federal commissions, and proper expenditures necessary to operation should enter into determination of rates. It is believed, therefore, that whatever readjustment of the burden of the cost of protection from railroad fires is desirable would be made most easily in the direction of the standard established in these three States. If the railroads are assured of fair adjustment of rates to proper expenditures, their chief obligation will be to adopt the most economical methods of operation consistent with a minimum of friction with the public and with adjoining property owners.

Maine provides also by statute that railroads are responsible for damages by fire caused by any employee.

The statutes of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and New York also authorize railroads to insure property adjacent to the right of way, and provide that they shall have an insurable interest in such property. The statutes of Maine, New Hampshire, and Massachusetts provide further that in case of damages by fire for which a railroad is held responsible it is entitled to any insurance effected by the owner of the property, less the premium and the cost of collection.

Liability for the Cost of Extinguishing Fires

Statutes placing liability upon the railroads for the cost of extinguishing fires caused by them have been enacted recently in New Hampshire, Massachusetts, Connecticut, New York, Maryland, Delaware, West Virginia, and Kentucky. The New Jersey statute authorizing the conservation commission to permit persons who have violated the fire law to pay the cost of extinguishing the fire in lieu of fine, is applied in practice to railroad fires. The West Virginia law, which was enacted by the last legislature, does not apply specifically to railroads, but to any person or corporation responsible for the escape of fire.

The New Hampshire statute provides very fairly that payment of bills by a railroad for fire fighting shall not be used as evidence that the fire was caused by the railroad, and the Connecticut statute specifies that the local and the State fire warden must approve accounts for fire fighting charged against the railroads. In New Hampshire and New York, in fact, the railroads customarily refer bills charging them for expenditures in fighting fires to the State officials for approval. New Hampshire and New York provide that expenses incurred even by individuals in fighting railroad fires must be paid by the railroads, whereas the statutes of the other States noted apply only to expenditures incurred by municipalities, counties, or the State.

The importance of claims for damages and of liability for the cost of extinguishing fires is great. In Massachusetts, for example, where the statute which requires the use of spark arresters and the clearing of the right of way fails to provide fine for violation, repeated claims have taught the railroads to exercise much care in complying with its specifications. Ability to impose a fine, however, arms the State administration with a more effective weapon for prompt action, and the effectiveness of the statutory precautions depends, of course, upon the possibility of enforcement by the forestry officials.

Devices to Prevent the Escape of Fire from Equipment

All of the States considered, except Vermont and Rhode Island, have enacted various statutes requiring the use of spark arresters and devices

to prevent the escape of fire from fire-boxes and ash-pans. The various provisions of the only Pennsylvania statute relative to forest fires caused by railroads in force previous to June 1, 1915, apply only to lines passing through forest lands on which there are oil or gas wells, but the law which became effective on that date confers power upon the State fire warden to issue reasonable orders relative to railroad operation in any part of the State.

The statutes of New Jersey and Kentucky are weakened by qualifying phrases. The West Virginia law was similarly weak, requiring only that spark arresters "shall give the best practicable protection against the escape of fire and sparks," but was amended by the last legislature so that locomotives must now be provided with spark arresters "so constructed and at all times maintained as to prevent the escape of fire and sparks." Laws like those of New Jersey and Kentucky serve only as general guides to courts and juries, and do not demand the use of efficient equipment. They were, in fact, enacted many years ago, primarily for the protection of buildings.

A law to be effective does not need to be specific as to the devices, but may be comprehensive, like the Maine statute, which makes escape of fire in any manner from a locomotive *prima facie* evidence that whatever devices have been provided are inefficient and that the law has been violated. The Maine law states very briefly:

"All locomotives which shall be run through forest lands shall be provided with approved and efficient arrangements for preventing the escape of fire and sparks," and a fine of $100 for each violation is provided.

The Connecticut statute just enacted is similarly brief and comprehensive. It also specifically authorizes inspection of locomotives at the discretion of the State forestry officials.

The law of Maine, also, and the laws of New Hampshire, Massachusetts, and New York require that spark arresters and other devices installed to prevent the escape of fire must be approved by public service or railroad commissions. The New York law is quoted:

"All said devices (a practical and efficient spark-arresting device, and adequate devices to prevent the escape of fire from ash-pans and furnaces) shall be approved by the public service commission, and shall at all times be maintained in good repair." . . . "The public service commission must, upon the request of the conservation commission and on notice to the person or companies affected, require any person, railroad, or other company having a railroad running through forest lands to adopt such device and precautions against setting fire upon its line as the public interest requires."

The State forester of New Hampshire advises that since the enactment of the spark arrester law in his State, the Boston and Maine Railroad has equipped 45 locomotives with the Mudge-Slater arrester, and that on the two branches where 75 per cent of the locomotives are so equipped the number of fires was reduced from 134 in 1913 to 21 in 1914.

Maine requires the use of screens on smoking-car windows between May 1 and November 10 within the forestry district, which comprises 9,500,000 acres, or two-thirds of the forest area of the State. The practice, however, is to fasten the windows down instead of providing screens. The statute recognizes a serious cause of forest fires.

The laws of Maine, New Hampshire, Massachusetts, New York, Pennsylvania, and West Virginia forbid leaving deposits of live coals near woodlands, and the New Hampshire law requires also the maintenance in efficient order of the devices provided to prevent the escape of fire from locomotives.

The Maine statute is quoted:

"No railroad company shall permit its employees to deposit fire, live coals, or ashes upon its track in the immediate vicinity of woodlands or lands liable to be overrun by fire," and a fine of $100 for each offense is provided.

The New Hampshire statute reads in part:

"Every railroad company . . . shall require its employees operating such engines (as are not operated by oil or electricity) to exercise due care to keep such (fire preventive) devices in good order."

The Right of Way

Statutes requiring removal of inflammable material from the right of way are in force only in Maine, Massachusetts, New York, Pennsylvania, Delaware, West Virginia, and Kentucky of the States considered. The Delaware statute, however, provides simply that every railroad is liable for damages caused by fires which originate in material which the railroad has allowed to remain on its right of way, and the Kentucky statute requires only that every railroad shall keep its right of way clear of "weeds, high grass, and decayed timber, which, from their nature and condition, are combustible material, liable to take and communicate fire from passing trains to abutting or adjacent property." Maine requires the removal of inflammable material each year; Pennsylvania at least once each year, and West Virginia at least twice each year. Massachusetts requires the right of way to be kept free from inflammable material, and New York requires the right of way to be cleared of inflammable material whenever ordered by the conservation commission.

The Maine law contains a commendable provision prohibiting railroad employees from burning rubbish along the right of way when forbidden by the forest commissioner or his wardens. The Massachusetts law endeavors to prevent possible misunderstanding by providing that it shall not be construed that any railroad corporation is prohibited from "piling or keeping upon its location or right of way cross-ties or other material necessary for the maintenance and operation of its railroad."

The requirement that inflammable material be removed once or twice a year serves as a useful guide, especially in States where strong public service or other administrative commissions have not been created, but it may foster perfunctory action by the railroads. New York, for example, until 1911 inclusive, required the removal of inflammable material twice a year throughout the State generally, but in the forest preserve counties, where the State officials had strong powers, required the removal of inflammable material whenever ordered by the forest commissioner.

A very strong form of law could be framed by combining with the Maine statute the requirement of the present New York statute, so that it would read, copying the Maine statute:

"Every railroad company whose road passes through waste or forest lands shall, during each year, and (copying the New York statute as italicized) *whenever required by the conservation commission*, cut and burn off or remove from its right of way all grass, brush, or other inflammable material, but under proper care and at times when fires are not liable to spread beyond control."

Authority to Railroads to Remove Inflammable Material from Land Adjoining the Right of Way

The removal of inflammable material from the right of way alone does not clear a strip wide enough to prevent the occurrence of fires caused by escaping sparks or coals. The legislation authorizing railroads to remove inflammable material from private lands adjoining the right of way has, therefore, been received with general commendation by the railroads, State officials, and property owners. It is particularly useful in enabling the railroads to secure immunity from the class of property owners which is inclined to bring unreasonable suits for imagined losses by fire. New Hampshire, Massachusetts, and Rhode Island are, however, the only States which have enacted legislation of this kind. The New Hampshire law authorizes clearing to a distance of 25 feet from the right of way, whereas the Massachusetts statute and the Rhode Island statute, which was copied from it, permit clearing to a distance of 100 feet from the tracks. All three laws require notification to be given to the owner of the

land, and the New Hampshire law also authorizes appeal by the owner from the intended action of the railroad. Appeal is filed with the public service commission, which may sustain or deny it, and may issue orders relative to the method of clearing to be adopted. The New Hampshire law provides that valuable timber growth shall not be removed without compensating the owner. The Massachusetts and Rhode Island laws apply specifically only to unimproved lands, and provide also that the clearing is subject to the direction of the local forest warden, who must be notified in advance by the railroad of its intention to clear any land. The statutes are not quoted on account of their length, but they do not differ in essential principle, and both types contain valuable suggestions for States interested in legislation of this kind. New Hampshire also authorizes railroads, upon approval of the public service commission, to acquire land adjoining the right of way in order to maintain it clear of inflammable material; but this privilege has not been taken advantage of.

Attention is directed to the New Jersey statute, Secs. 56-63, 2 Comp. Stat., pp. 2339-2340 (Pub. Laws 1909, pp. 102-105), declared unconstitutional by the court of last resort in 1913 (Vreeland *v.* Forest Commission, 12 Buchanan, 349) on the ground that it provided for an unwarranted invasion of property rights. The State fire warden states that although the law was at first severely opposed by all the railroads operating in the State, by the time of its reversal it had become very popular, and that now, with but two exceptions, the railroads through their own initiative are continuing the construction of the fire lines as prescribed by the law.

The value of this law for present purposes is simply in the method of fire-line construction which it suggests. In detail, it required the maintenance of a plowed strip not less than 10 feet wide, cleared of all inflammable material, to be located at a distance of not less than 100 or more than 200 feet from the track on each side. As a substitute in swamps, a ditch at least 3 feet wide dug to permanent water was permitted. Between these strips inflammable material was to be burned once annually between November 1 and March 1, except that trees more than 3 inches in diameter and not less than 6 feet apart were not required to be cut, but were to be pruned of branches to 6 feet from the ground. The law gave the forest commission authority to permit the omission of the fire line or the re-clearing of the same in places where, in its judgment, the making or re-clearing was unnecessary, and provided also that the construction of fire lines on private property was subject to the discretion of the commission. Fire line construction was required on only one-fifth of the woodland frontage of each railroad annually. The law

provided that nothing contained in it should bar action against a railroad for damages by fire.

Removal of Slash by Private Owners from Strips Adjoining Railroads and Other Fire Lines

Although practice has imposed upon the railroads the expense of removing inflammable material from private lands adjoining the right of way, it is obviously unfair that abutting owners should be allowed by their own action to increase the susceptibility of their lands to fire. Accordingly, statutes have been enacted in Maine, New Hampshire, and Massachusetts requiring the disposal of slash from logging on land adjoining the rights of way of railroads. Pennsylvania, also, since 1907, has required owners or operators of forest lands on which there are oil or gas wells to remove at least once a year all inflammable material within 100 feet of any railroad and within 100 feet of each oil or gas well.

The New Hampshire statute as amended by the last legislature requires removal of slash within 60 days, so that it will not remain within 40 feet of the right of way of any steam railroad, or within 20 feet of the right of way of any electric railroad or of the traveled part of any public highway, but permits postponement of the slash disposal in some of the northern counties until not later than April 1, and in others until not later than May 1 each year. The original act applied only within 25 feet of the right of way of a steam railroad. The law does not relieve the lumber operator from responsibility for the escape of fire as provided by the general statutes of the State.

It is noteworthy, also, that New Hampshire since 1901 has required care in burning brush resulting from cutting along highways, and that the last session of the legislature of Connecticut enacted a law authorizing the forest fire wardens to require disposal of any slash made within 15 feet of the traveled portion of a highway.

The Massachusetts law requires disposal of slash within 40 feet of a railroad location and also within 40 feet of a highway or of the woodland of another as directed by the local forest warden. The bill, as originally drafted, stipulated 100 feet instead of 40 feet as enacted in the law, and it is certain that the width of strip will sooner or later be increased. The Massachusetts law provides a fine of \$5 to \$50 for each offence, whereas the New Hampshire law provides a fine of \$10 for each acre or fraction on which disposal of the slash is neglected.

These two laws represent a decided advance in fire-protective measures, and are generally considered as fair and sound in principle. It may be questioned whether many States have yet developed a strong enough per-

sonnel of forest wardens to secure efficient administration of a law like that of Massachusetts.

The Maine law, just enacted, resembles somewhat the New Hampshire law in that it provides that if the trees within 50 feet of a railroad right of way are cut, the debris must be disposed of so that it will not remain within this distance of the track. It requires also the disposal of the slash caused by the construction of railroads, highways, and telephone and telegraph lines. The forest commissioner is authorized, upon violation of the law, to undertake the necessary disposal of slash and to collect the cost thereof from the responsible party. Postponement of slash disposal until spring is permitted.

Reporting of Fires

Train crews are required by statute in Maine, New Hampshire, Massachusetts, New York, and West Virginia to report fires discovered by them. As this is a matter which involves no expense and little inconvenience to the railroads, and may occasionally obviate expensive damage suits, they have generally shown willingness to report fires even in States where no statutes require it. The Massachusetts law is the most complete. It requires train employees who have discovered a fire burning uncontrolled near the track to cause a whistle signal, consisting of one long and three short blasts, repeated several times, to be sounded from the engine. This signal would, of course, be sounded also, after discovery of a fire, when the train passed section men or a station. The fire whistle was used recently on the Boston and Maine Railroad by the crew of a freight train on which there was a burning car to call out the local fire department as the train approached a town.

The New Hampshire law authorizes the public service commission to issue rules pertaining to the giving of signals. The State forester of New Hampshire advises that the Maine Central has a rule which requires the engineer to drop a fire card, on which he has written the location of any fire he has discovered, to the next section crew he passes. The fire card is a piece of cardboard with a metal attachment to give it weight enough to throw from the engine. These methods of reporting fires obviate necessity for special stops.

Extinguishing of Fires by Railroads

The efficient extinguishing of fires by railroads is closely corollary to the degree of responsibility to which they are held for fires generally. Maine, New Hampshire, Massachusetts, Connecticut, New York, Pennsylvania, and West Virginia have enacted statutes pertaining to this sub-

ject. The Maine statute, however, applies simply to railroad construction, making it a misdemeanor for employees to leave fires unextinguished. The New Hampshire statute authorizes the State forester to appoint as deputy forest fire wardens section foremen or other employees recommended by the railroads. The railroad deputies so appointed have the same powers as other deputy forest-fire wardens, but are responsible only for the extinguishing of fires which originate along the right of way.

The Massachusetts, Connecticut, and West Virginia statutes are somewhat similar, and in general require section men or other employees to use all practicable means to extinguish fires along the right of way. The Massachusetts statute provides that railroad employees shall not be required to leave work necessary for the safety or convenience of traffic. This prudent provision has not, however, prevented satisfactory action by railroad employees in extinguishing fires. New York states its requirements briefly as follows:

"Station agents (notified of fires along the right of way) shall notify the nearest fire warden (or ranger) thereof, and use all necessary means to extinguish the same," and imposes penalty for violation.

Pennsylvania, also, simply requires railroads to use all practicable means to put out fires within 100 feet of their tracks where they pass through forest lands on which there are oil or gas wells.

The New Hampshire, Connecticut, and New York officials have found the extinguishing of fires by railroads not entirely satisfactory, although improving. Inefficiency has been due to inexperience or indifference on the part of employees rather than to unwillingness to co-operate on the part of the railroad authorities. In New Hampshire it has been found that the machinists and similar employees hurried out to extinguish large fires do not know enough about the work to be of use. The Massachusetts proviso already noted takes into account the essential difficulty in depending upon railroad employees to extinguish fires, namely, the greater importance of their other duties. It is noteworthy, however, that the satisfactory attention given by section men to the extinguishment of fires in Massachusetts is due undoubtedly to the strict accountability for damages to which the railroads in that State have been held.

Patrol at Railroad Expense

The statutes of Maine, New Hampshire, New York, New Jersey, Pennsylvania, and West Virginia require patrol at railroad expense during periods of danger. The only Pennsylvania statute in force until this year merely required the employment of sufficient trackmen from April 1

to May 20 and from September 10 to November 10 annually (thus assuming that fires would occur only within those periods) to put out fires promptly on the right of way where railroads passed through forest lands on which there are oil or gas wells, but in the opinion of the writer the law enacted by the last legislature authorizes the State fire warden to require patrol in any part of the State if, in his opinion, it is the most effective method of overcoming a fire hazard. West Virginia requires railroads to employ in seasons of drought and before vegetation has revived in the spring sufficient trackmen to put out fires on the right of way where the tracks pass through forest lands or lands liable to overrun by fire.

The Maine, New Hampshire, and New York laws have been found satisfactory. The New Hampshire law, notwithstanding the fact that, like the West Virginia law, it leaves determination as to the need of patrol to the railroads, is efficient undoubtedly because the railroads have been forced by the courts to comprehend that fire prevention is cheaper than the payment of claims.

The Maine and New York statutes require patrol at the direction of the State forestry officials. The Maine law is the simpler and is thoroughly efficient. The last legislature, in fact, extended its application from the forestry district to the entire State. The laws of both States contain details particularly worthy of examination. They both provide that adequate patrol may be maintained by the forestry official or officials of the State at railroad expense if the railroad has neglected to establish it when ordered. These laws provide for detailed reports of fires by the patrolmen to the State forestry officials and for the collection by the State of the amounts expended by it in patrol. Previous to 1909 only one-half of the cost of patrol in New York was a railroad charge, the other half being a public charge.

The New Jersey law was enacted by the last legislature and is a notable advance in legislation of this kind. It applies to conditions of any kind which tend to originate forest fires, authorizing the State forestry board to require the maintenance of satisfactory patrol at the expense of the parties responsible for the dangerous conditions. The law provides for division of expense when more than one party is responsible for the hazard in any locality. Unlike the Maine and New York laws, it is enforceable through penalties, and does not authorize the State officials to establish the necessary patrol at the expense of those responsible.

The ultimate necessity for the enactment of similar laws in other States depends upon the ability of the railroads to interpret public demands for protection against forest fires. In a number of States where

compulsory patrol does not exist the railroads have voluntarily established some patrol during dangerous periods.

Compulsory Inspection of Locomotives

The only statute requiring compulsory inspection of locomotives was enacted in New York in 1912. This law requires superintendents of motive power on railroads acting as common carriers to appoint employees whose duty it shall be to examine each locomotive each time that it leaves a division point or round-house and to submit reports upon its condition for the examination of officials of the conservation commission. The conservation commission may also order the rejection from service after 5 days' notice of locomotives found to be defective. Appeal from the order of the conservation commission to the public service commission is provided, but locomotives condemned by the former commission cannot be used pending decision. Penalties are provided for violation of the statute. The conservation commission has not found it necessary to order the rejection from service of locomotives, as the railroads take proper action when informed that locomotives have been found to be defective.

In most States locomotives are inspected by the forestry officials as occasion may necessitate. The New York law providing compulsory inspection resulted from long-standing neglect on the part of the railroads to give the matter of forest protection due consideration. The necessity for similar legislation in other States depends largely on the policy pursued by the railroads. The experience of New York proves that compulsory inspection is a most satisfactory method of preventing the setting of fires by coal-burning locomotives, and it should be kept in mind by States struggling with inefficiently managed railroads.

Orders and Regulations by Public Service or Other State Commissions

In Maine, New Hampshire, Massachusetts, New York, New Jersey, and Pennsylvania public service or other State commissions or officials have specific authority by statutes already noted to regulate railroad equipment or operation in order to prevent the occurrence of forest fires. In Maine the railroad commission is authorized to issue orders and regulations pertaining to the operation and equipment of locomotives upon information from the forest commissioner that there is danger of fire to forest lands within the forestry district. In New Hampshire and Massachusetts spark arresters must be provided and maintained subject to the approval of the public service and railroad commissions respectively, and in New Hampshire the regulation of fire signals is placed with the public service commission.

The New York statutes establish the powers of the conservation commission and of the public service commission to regulate patrol, the removal of inflammable material from the right of way, the installation and maintenance of devices to prevent the escape of fire from locomotives, the adoption of devices and precautions against the setting of fire necessary to the public interest, and the rejection from service of defective locomotives. It may be noted that the important and comprehensive function imposed by the New York law upon the public service commission, namely, the duty of requiring the adoption by the railroads of precautions and devices necessary for fire prevention, as essentially the same purpose as that for which authority is vested in the Maine railroad commissioners. The New York statute, however, is mandatory, and requires that action must be taken upon request of the conservation commission, whereas the Maine statute merely authorizes the railroad commissioners, upon request of the forest commissioner, to take such action as they deem necessary. The New York statute provides, therefore, much stronger control. Under this law the commission was enabled to end the hopeless struggle to secure effective protection against the setting of fires by coal-burning locomotives in certain kinds of traffic in the Adirondacks by ordering the use of oil as fuel. The New Jersey statute, however, offers a procedure which has the virtue of being more direct than either that of Maine or that of New York, in that authority to act is vested entirely in the conservation commission.

The law enacted by the last legislature of Pennsylvania requires the railroads to put into effect reasonable regulations deemed necessary by the chief forest-fire warden and approved by the public service commission. The word "reasonable" generally opens the door for an argument, but it is too early to discuss the effectiveness of this law, since it reorganizes radically the fire-protective system of the State.

The general regulation of railroads by public service commissions in many States has been adequate to bring about the establishment and maintenance of efficient fire-protective measures. The regulation of railroads by commission is a broad subject, but the experience of New York in securing adequate protection against locomotive fires deserves the attention of the railroads and of other States alike.

Special Legislation Relative to Public Reservations

It is interesting to note that the much and justly maligned constitutional provision of New York has been found by the State officials to be responsible for extremely bad conditions along railroads in the Adirondack and Catskill State forest preserves, since it forbids sale or removal

of any timber, slash, or other inflammable material from the State lands. Massachusetts, under the act which authorizes railroads to remove inflammable material outside of the right of way to a distance of 100 feet from the track, does not extend authority to enter public reservations for this purpose and forbids interference in any way with the management of them.

Résumé

Review of the legislation designed to prevent the occurrence and spread of forest fires caused by railroad operation leads to the following conclusions: That inasmuch as legislation and the decisions of the courts have constantly augmented the liability of the railroads for damages and for the cost of extinguishing the fires caused by them, there would be decided advantages to all concerned in uniformity, in so far as local conditions warrant, in (1) the liability to which the railroads are held for damages by fire and for the cost of extinguishing the fires caused by them; (2) the requirements pertaining to devices designed to prevent the escape of fire from locomotives; (3) the requirements pertaining to the removal of inflammable material from the right of way; (4) authorization of railroads to enter upon private land adjoining the right of way to construct fire lines and to remove inflammable material, and (5) the requirements pertaining to the disposal of slash by private owners adjacent to the right of way. There would also be advantages in uniformity in the simpler matter of the method of reporting fires discovered by train crews.

Where railroads persist in disregard of the interests of the State and of adjoining property owners, compulsory patrol at railroad expense during periods of danger, compulsory inspection of locomotives, and even the use of oil as fuel may be necessitated. The efficiency of the protection secured by public service commissions or other administrative officials authorized by comprehensive legislation to issue orders or regulations relative to the details of railroad operation is also significant.

LUMBERING

Portable Engines

New Hampshire, New York, Maryland, Delaware, and Kentucky have statutes which require the use of spark arresters and devices to prevent the escape of fire from portable engines. The New Hampshire law makes it a misdemeanor to operate a portable steam mill except when the ground is covered with snow, unless the mill is provided with a spark arrester approved by the State forester. The Maryland statute and

chapter 71, Laws of Delaware, 1909, make it a misdemeanor to operate near forest lands an engine which does not burn oil as fuel, unless it is provided with appliances to prevent the escape of fire from smokestack, ash-pan, and fire-box. The New York and Kentucky laws are weakened by qualifying phrases to the effect that spark arresters need be efficient only as far as practicable. A law combining the requirement that devices be approved by the State forester, as in New Hampshire, with the comprehensiveness of the Maryland statute would be very strong. The problem of preventing the escape of fire from portable engines is similar to that of preventing the escape of fire from locomotives. Chapter 243 of the Laws of Delaware, 1909, is a striking example of legislation which provides requirements in too much detail. It requires every traction engine to be provided with "a suitable and sufficient spark catcher or spark protector, which spark catcher or spark protector shall be of a conical or funnel shape and of a heavy wire material and of a mesh not larger than one-eighth of an inch." This particular form of spark arrester might, on the one hand, prove impracticable for efficient operation of the engine, or, on the other hand, inadequate for protection against the escape of fire.

The need of legislation requiring spark arresters on portable engines has been felt in Massachusetts, and there seems to be no good reason why there should not be uniform legislation on this subject.

Slash Disposal

Legislation requiring the general disposal of slash by lumbermen has been enacted only in New York, New Jersey, and Pennsylvania of the States considered. The New York law, enacted in 1909, requires that in certain towns (in the forest preserve counties) the limbs of evergreens felled shall be lopped to a diameter of 3 inches in the tops unless the trees are to be sold with the limbs on, but authorizes the conservation commission to allow the postponement or omission of the lopping. This law has afforded marked improvement in reducing the liability of cut-over lands to ravage by uncontrollable fires, as the lopped tops rot down thoroughly in two or three years.

The New Jersey law (chap. 61, Laws of 1915) resembles laws enacted in Minnesota, Oregon, and other western States. It authorizes the State forestry officials to declare any accumulation of slash to be a public nuisance and to require disposal thereof. It differs from the laws of some of the western States, however, in that it simply imposes penalties for violation, and does not authorize the State officials to dispose of the slash at the expense of the responsible party.

The new Pennsylvania law already noted in reference to the authority it provides for railroad regulation, is similar to the New Jersey law, but is more comprehensive, authorizing the State fire warden to declare "any property . . . (and specifically railroad property), by reason of its condition or operation," to be a public nuisance. New Jersey's new law (chap. 109, Laws of 1915) authorizing the forestry officials to require patrol at the expense of those responsible of any place where forest fires are likely to originate, has already been noted. This law and the Pennsylvania law resemble in purpose chapter 247, Laws of Oregon 1913, which specifically authorizes the State officials to require patrol of dangerous slashings.

The Massachusetts law already noted relating to the disposal of slash along railroads and highways requires also the disposal of slash on a 40-foot strip adjoining every property line. This law is suggestive of the possibility that the construction of fire-breaks by the disposal of slash along frequent strips would prove a practical and effective method of overcoming the fire hazard in many sorts of conditions.

Slash disposal laws have been enacted upon the broad principle that the State has authority in its police function to require such management of private property as is necessary to protect the property of others or of resources valuable generally to the public welfare. In so far as funds are appropriated from the treasury of the State to protect forests from fire, it is clearly just that the land-owners should be required so to manage their property as to reduce to a minimum the possibility of the occurrence and spread of fires. The decision of the supreme judicial court of Maine, March 27, 1907, 103 Maine, 506, affirms that legislation enacted to regulate the cutting of trees on wild lands in order to protect the waters of the State would be constitutional, but no advantage of this decision has been taken to enact restrictive legislation.

Every State is vitally concerned to protect its forest resources, present or future, from the great and frequently irreparable injury which is caused by forest fires, and those which contain extensive coniferous forests may, therefore, direct their attention very wisely to the problem of slash disposal.

The wide variation in conditions which exists even within State boundaries necessitates decided individuality in the methods of slash disposal which should be prescribed by law. A bill introduced in the Wisconsin legislature, for example, similar to the earlier slash law in Minnesota, which required burning of slash annually before May 1, was defeated because the larger proportion of hardwood and hemlock over pine in Wisconsin made the burning of green slash impracticable, although the de-

feat of that bill does not indicate that improvement in methods of slash disposal in Wisconsin is not necessary. The difficulties which ensue from rigid requirements as to slash disposal are, however, unnecessary, since the State forestry official may be provided with authority to permit reasonable modification in method.

STATUTES NOTED

RAILROAD OPERATION

Maine—

Sec. 73, Chap. 52, Rev. Stat. 1903.

Secs. 60-64, Chap. 7, Rev. Stat. 1903, as amended by Chaps. 86 and 177, Laws 1913.

Chap. 35, Laws 1911, as amended by Chap. 68, Laws 1915.

Chap. 196, Laws 1915.

New Hampshire—

Sec. 29, Chap. 159, Pub. Stat. 1900.

Chap. 155, Laws 1913, as amended by Chap. 100, Secs. 2-4, Laws 1915.

Chap. 125, Laws 1913.

Chap. 98, Laws 1901 (Highways).

Vermont—

Sec. 4510, Pub. Stat. 1906.

Massachusetts—

Sec. 247, Part 2, Chap. 463, Laws 1906.

Secs. 1-2, Chap. 394, Laws 1909.

Chap. 431, Laws 1907.

Sec. 1, Chap. 101, Laws 1914.

Rhode Island—

Sec. 14, Chap. 395, Sess. Laws 1909.

Connecticut—

Secs. 3779-3780, Gen. Stat. 1902, as amended by Acts 1911, Chap. 212.

Chap. 114, Acts 1911.

Chap. 322, Acts 1915.

Chap. 260, Acts 1915 (Highways).

New York—

Secs. 97-98, 101-103, 105, Part 2, Art. 4, Conservation Law 1915.

Constitution, Art. 7, Sec. 7.

New Jersey—

3 Comp. Stat. 1910, pp. 4245-4246, Secs. 56-58.

2 Comp. Stat. 1910, p. 2335, Sec. 49, as amended by Sec. 7, Chap. 36, Laws 1911.

Chap. 109, Laws 1915.

Pennsylvania—

Secs. 38-39, 5 Digest of Laws, "Forests and Timber."

Sec. 41, 2 Digest of Laws, "Forests and Timber" (Act of April 18, 1794).

Act 353, Laws 1915.

Maryland—

Secs. 307-310, Art. 23, Pub. Gen. Laws 1911.

Secs. 12-13, Art. 39-A, Pub. Civ. Laws 1911 (Chap. 294, Sess. Laws 1906).

Delaware—

Sec. 2, Chap. 380, Sess. Laws 1881 (Rev. Stat. 1893, Chap. 128).

Secs. 12-13, Chap. 71, Sess. Laws 1909.

West Virginia—

Chap. 62, Sec. 54-54*a*, Code 1915.

Kentucky—

Secs. 25-26, Chap. 133, Laws 1912.

Sec. 790, Chap. 32, Carroll's Kty. Stats. 1909 (Sess. Laws 1893, pp. 612, 706).

LUMBERING

PORTABLE ENGINES

New Hampshire—

Chap. 95, Laws 1911.

Massachusetts—

Sec. 1, Chap. 101, Laws 1914.

New York—

Sec. 106, Part 2, Art. 4, Conservation Law 1915.

Maryland—

Sec. 12, Art. 39*a*, Pub. Civ. Laws 1911.

Delaware—

Sec. 1, Chap. 243, Sess. Laws 1909.

Sec. 12, Chap. 71, Laws 1909.

Kentucky—

Secs. 25-26, Chap. 133, Laws 1912.

SLASH DISPOSAL

New York—

Sec. 90, Part 2, Art. 4, Conservation Law 1915.

New Jersey—

Chaps. 61 and 109, Laws 1915.

Pennsylvania—

Act 353, Laws 1915.

Minnesota—

Sec. 15, Chap. 182, Sess. Laws 1909.

Sec. 4, Chap. 159, Sess. Laws 1913.

California—

Chap. 392, Acts of 1911.

Idaho—

Sec. 1606, Chap. 4, Title 9, Pol. Code, as amended by Acts of 1909.

Oregon—

Sec. 11, Chap. 278, Laws 1911.

Chap. 247, Laws 1913.

Washington—

Chap. 125, Laws 1911.

REVIEWS

Natural Revegetation of Range Lands Based upon Growth Requirements and Life History of the Vegetation [1]

A careful reading of Sampson's paper on "Natural Revegetation of Range Lands Based upon Growth Requirements and Life History of the Vegetation" should be of the utmost benefit to the forester, since it almost unconsciously brings up a comparison between the present economic status of the grazing industry and the lumber industry. It shows very clearly that there is a close similarity in the fundamental laws underlying both grass and timber growth and at the same time a wide economic difference in the utilization of these two important resources on the National Forests. The range lands, like the timber lands, if they are to be economically used, must be managed on a continuous sustained yield basis. The sustained yield management rests, in timber lands as well as in grass lands, on a clear understanding of the growth requirements and life history, in one case, of trees; in the other, of grasses. There is, however, this essential difference: the life cycle of the herbaceous vegetation is very short, even in the case of perennial grasses, while the life cycle of a forest may extend over two or more generations of men. This difference in the life cycle of the two groups of plants with which the grazing expert and the forester deal makes the task of the grazing man much easier than that of the forester. There is another difference of an economic character: While the demand for range is greater than its supply, and should there be any vacant range land, the grazing industry is capable of immediate expansion to utilize that new range, the supply of timber, at least at present, is far greater than its present demand. The increase in the productiveness of the range and its utilization can be accomplished within a few years. Neither the growing of timber nor its utilization lends itself to such immediate expansion. This difference in the economic condition of the two industries affects to a large measure the character of grazing and forest investigations in their application in actual life. The results of grazing investigations are possible of immediate application, since the grazing industry demands immediate and greater productive capacity of range, so as to provide more room for the growth of the industry, and

[1] Sampson, Arthur W. Journal of Agricultural Research. Vol. III. No. 2, pp. 93-147. U. S. Department of Agriculture, Washington, D. C., 1914.

therefore there is the closest relation between the grazing investigations and their immediate application. In forestry, since the need for increased growth in the presence of a still large over-mature timber supply which cannot be marketed is not actually felt at present, all forest investigations leading toward an increase in the productiveness of the forest soil must necessarily remain largely academic for the present. It must be borne in mind, however, that just from the nature of the plants with which the grazing expert and the forester deal forest investigators cannot secure results in as short a time as grazing. If, therefore, the results of forest investigation are ever to be applied to the management of our forests, as they inevitably must in the near future, the time to begin such investigations is right now; and if there may be temporary discouragement on the part of the forester that his present investigations may not be as seriously taken as grazing investigations, which can be immediately put into practice, he must console himself with the thought that he is building a basis for the future when the results of his investigations will be badly needed.

Sampson's study is a splendid illustration of the application of scientific methods of plant investigation to a very definite practical problem of range management. The same results probably could have been accomplished empirically by trying first one method of handling sheep and then another, and after long trials the system of deferred grazing as proposed by Sampson would be finally accepted. But what would have taken many years to work out empirically, and yet without any solid knowledge of the reasons why the system of deferred grazing should be adopted, the study of the life habits of the forage plants furnished within a short time a reliable basis for the new system of grazing which made available large areas for grazing without deterioration of the range itself. How to utilize the range most economically and yet to interfere as little as possible with its natural revegetation is the problem which Sampson's study is to answer. On the basis of the life history of the grasses composing the range, his answer was that on areas in need of revegetation grazing should be deferred until the grasses have completed their seed production. He found that grazing after seed maturity in no way interferes with flower-stalk production, and that as much fertile seed is produced as where the vegetation is protected from grazing during the whole of the year.

On the other hand, the removal of the herbage year after year during the early part of the growing season weakens the plants, delays the resumption of growth, advances the time of maturity, and decreases the seed production and the fertility of the seed. If viable seed is to be pro-

duced, therefore, the vegetation must not be regularly deprived of its leafy foliage during the critical growing and food-storing period. Yearlong protection of the range favors plant growth and seed production, but does not insure the planting of the seed. Moreover, it is impracticable because of the entire loss of the forage crop and the fire danger resulting from the accumulation of inflammable material. Deferring grazing until after seed maturity insures the planting of the seed crop by the hoofs of the sheep and the permanent establishment of seedling plants without sacrificing the season's forage or establishing a fire hazard. Deferred grazing can be applied wherever the vegetation remains palatable after seed maturity and produces a seed crop, provided ample water facilities for stock exists or may be developed. This necessitates a knowledge of the beginning of normal spring, formation of flower stalks, and seed ripening at the different altitudes of the range as a basis for regulating the grazing. In the region studied the spring growth of forage plants normally begins in the Hudsonian zone about June 25; flower stalks are produced approximately between July 15 and August 10, while the seed matures between August 15 and September 1.

As to the study itself, it has been carried out with great thoroughness, possibly even with more finesse than was necessary to secure the basic facts. The author still retained Merriam's division of vegetation into Arctic-Alpine zone, Hudsonian zone, Canadian zone, and Transition zone. The yellow-pine type, the lodgepole-pine type, the whitebark-pine type, and the Alpine meadow type would convey more clearly to the forester, at least, the climatic belts in which the study has been conducted.

RAPHAEL ZON, F. E.

FOREST SERVICE, *October* 4, 1915.

This is one of the few papers by a member of the Forest Service to be accepted by the Journal of Agricultural Research,[1] a journal which accepts only researches contributing original data. It has revolutionized the grazing industry by the discovery of a method of restoring depleted range without excluding grazing and consequently without hardship to the grazing industry.

The significance of these two points should be considered for a moment. First, it is noteworthy that Sampson is an ecologist rather than a forester, and that his work deals with herbs rather than with trees. The relation

[1] This paper gives the data upon which Bulletin 34 of the U. S. Department of Agriculture, "Range Improvement by Deferred and Rotation Grazing," are based. Bulletin 34, being intended for popular use, omits much of the detailed data which the paper in the Journal of Agricultural Research contains.

between an herb and its environment is, for obvious reasons, more easily studied than the relation between a tree and its environment. Therefore it is but reasonable to expect that researches in the natural factors controlling vegetation will make more rapid progress in grass lands than in forests. These researches have already begun to discover fundamental laws applicable to trees and shrubs as well as herbs.[2] The work requires, however, men with a broad, thorough training in plant physiology, ecology, botany, physics, and chemistry, as well as skill in handling delicate instruments, and a natural talent for original investigations. Such a training no forester receives at present in our forest schools; but fortunately several men at least, and Sampson is one of them, have had the unusual opportunity of preparing themselves for this class of work. We earnestly hope that these men will be allowed to add to the sum of original knowledge rather than be forced, as there seems to be imminent danger that they will be, into so-called "practical" problems, which serve a passing and sometimes urgent need, but contribute little or nothing to the sum of scientific knowledge. An efficient and far-sighted policy would place men with the usual forestry training upon the problems which have an immediate bearing on the handling of the National Forests, and allow those with special training and inclinations the freedom to work on the deeper problems and obtain results which, while possibly not of immediate application, will form a basis of scientific facts upon which to work out the other problems.

The paper under review represents a happy combination of the basic problem with immediate use. A study of the ecology and life history of the forage plants has given an immediate basis for developing a new system of grazing.

Practically all of the National Forests except those of the Pacific coast covered with heavy Douglas fir are of value as range for cattle, sheep, or goats. The forester in the Government service must therefore understand grazing as well as timber. Although each line of work is handled in its broad features by experts, the details of both lines fall upon the supervisors and rangers. Much of the range was overgrazed when taken over

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[2] Briggs, L. J., and Shantz, H. L. "The Wilting Coefficient for Different Plants and its Indirect Determination." U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 230, 1912.

Shantz, H. L. "Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area." U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 201, 1911.

Livingston, B. E., and Hawkins, L. A. "Water Relation between Plant and Soil." Carnegie Institute of Washington, Publication 204, 1915; also a number of other works.

by the Forest Service, and the restoration of this range to its normal capacity has always been a difficult problem. The total exclusion of stock and artificial reseeding were the only alternatives before Sampson's work was undertaken. Artificial reseeding was expensive and by no means sure of success;[4] total exclusion, even though it had involved only parts of the range at a time, had two drawbacks: First, it would have caused hardship to the grazing industry; second, it would have increased the danger of forest fires through the accumulation of tall grass.

The region in which the study was made is mountainous, which means great differences in vegetation, due to differences in climatic factors between points of different elevation. The first problem, therefore, was to find some basis for dividing the region into areas, each reasonably uniform within itself. The author solves this problem by the use of Merriam's life zone[5] without stating his reasons. It is obvious, however, that whatever may be the disagreement concerning the basis of Merriam's system, the zones here fit the conditions. None of the newer systems[6] have been worked up in sufficient detail to use in this particular case. Sampson could have used simply altitude, stating the climatic conditions, but apparently wished to give a basis which could be used elsewhere, where the actual altitude of the vegetative zones is different, but where Merriam's zones can be recognized.

Under climate he gives temperature, precipitation, comparative humidity, and evaporation. Temperature was found to diminish and precipitation to increase with increasing altitude. The evaporation in the Hudsonian zone at 7,400 feet was found to exceed that in the Canadian zone at 5,300 feet—a fact which he accounts for by the dense timber of the Canadian zone. The data secured are interesting, but the discussion of it leaves something to be desired. He states, in conclusion (p. 100), that in the "Hudsonian zone, as compared with the lower grazing type, the temperature is lower, the precipitation heavier, and the transpiration less." It is open to question whether or not, with a higher evaporation and greater insolation (though he does not mention insolation), the transpiration in the Hudsonian zone is less than in the lower zones.

The central theme of the paper is the life history of the forage plants.

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[4] For reseeding of cultivated forage plants see Sampson, A. W. "Reseeding of Depleted Grazing Lands to Cultivated Forage Plants." U. S. Department of Agriculture, Bulletin 4.

[5] Merriam, C. Hart. "Life Zones and Crop Zones of the United States." U. S. Department of Agriculture, Biological Survey Bulletin 10, 1898; also National Geographic Magazine, Vol. 6, pp. 229-238, 1894.

[6] Livingston, B. E. "Climatic Areas of the United States as Related to Plant Growth." Proceedings of the American Philosophical Society, Vol. 52, No. 209, 1913.

subdivided into five headings: (1) inception of growth, (2) flower-stalk production, (3) development and maturity of seed, (4) viability of the seed crop, and (5) establishment of reproduction. The effect of overgrazing upon each of these phases in the development of the forage crop was carefully studied and was found to be detrimental in each case. Vegetative growth and seed production, as well as the viability of the seed itself, were greatly reduced by the weakening of the plant, which inevitably follows constant close cropping. This meant an undue proportion of bare ground and an insignificant reproduction of the more desirable plants (pp. 118 and 119). The influence of complete exclusion of all grazing and of grazing only after the seed crop became mature were then studied. Under complete exclusion of grazing the vigor of the plants increased, flower stalks and seed were produced earlier and in larger quantities, and the seed itself had a higher percentage of fertility; but reproduction was not secured because the seed was not worked into the ground. Under the method of deferred grazing, waiting until the plants had produced seed, the recovery of the weakened plants was the same as under complete exclusion, and reproduction was secured by the covering of the seed through trampling by the sheep.

The method of deferred grazing, therefore, proved doubly successful, in that it gave a means of restoring the depleted grazing lands and at the same time of utilizing the forage crop. The grasses after seed maturity are less eagerly grazed than when young and tender. But chemical tests showed, although the mature plant is 27 per cent less rich in ether extract (fat) than the young plant, yet when compared with timothy hay mature mountain bunch-grass contains 94 per cent more protein, about the same amount of ether extract, and 50 per cent less crude fiber.

"Deferred grazing can be applied," Sampson says, "wherever the vegetation remains palatable after seed maturity and produces a seed crop, provided ample water facilities for stock exist or may be developed. The proportion of the range which should be set aside for deferred grazing is determined by the time of year the seed matures. In the Wallowa Mountains one-fifth of the summer grazing season remains after the seed has ripened, and hence one-fifth of each range allotment may be grazed after that date." Under this system a different part of the range is revegetated by deferred grazing every few years. When an area has been treated this way long enough to be completely restored, three or four years, or whatever period may be required, another area is treated in the same way until the entire range has been covered. Then it will be time to return again to the first area.

An interesting feature of this paper is that it appears several years after the results which it brings forth have been widely known and put into actual practice. This is merely one of a number of examples of the slowness with which the Government publishes its findings. Private institutions give out their results as soon as the work has been completed. The Government withholds its information sometimes for several years: sometimes altogether. Government research men are loaded down with valuable data which they are not allowed time to work up and publish.

BARRINGTON MOORE.

NEW YORK, *October*, 1915.

NOTES ON SANIO'S LAWS FOR THE VARIATION IN SIZE OF CONIFEROUS TRACHEIDS

Based on the results of an investigation of the tracheids of Scotch pine (*Pinus sylvestris*), Sanio[1] deduced five general laws relative to the variation in size of coniferous tracheids, as follows:

"1. In the stem and branches the tracheids everywhere increase in size from within outward, throughout a number of annual rings, until they have attained a definite size, which then remains constant for the following annual rings.

"2. The constant final size changes in the stem in such a manner that it constantly increases from below upward, reaches its maximum at a definite height, and then diminishes toward the summit.

"3. The final size of the tracheids in the branches is less than in the stem, but is dependent on the latter, inasmuch as those branches which arise from the stem at a level where the tracheids are larger themselves have larger tracheids than those which arise at a level where the constant size is less.

"4. In the gnarled branches of the summit the constant size in the outer rings increases toward the apex, and then falls again, but here irregularities occur which may be absent in regularly grown branches.

"5. In the root the width of the elements first increases, then falls, and next rises to a constant figure. An increase in length also takes place, but could not be exactly determined."

Bailey and Shepard[2] tested the validity of Sanio's first two laws with *Pinus strobus, Pinus palustris, Picea rubens, Tsuga canadensis,* and *Abies concolor.* This investigation shows that Sanio's first law does not hold for the species studied, and the authors even cast some doubt upon

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[1] Sanio, Karl. Über die Grösse der Holzzellen bei der gemeinen der Kiefer (*Pinus silvestris*). Jahrb. Wiss. Bot., 8: 401-420, 1872.

[2] Bailey, Irving W., and Shepard, H. B. Sanio's Laws for the Variation in Size of Coniferous Tracheids. Botanical Gazette, 60: 66-71, 1915.

the accuracy of his observations upon Scotch pine. The tracheids increase in length rapidly for a period of from 25 to 60 years. There is then a marked falling off in the length of the tracheids, lasting for a decade or even longer, and subsequently again increasing in length. The fact that alternating cycles of crests and depressions are produced suggests the possibility that the size of tracheids may be as sensitive to modifying climatic factors as the width of the annual ring is to rainfall.

Sanio's second law was found equally applicable to *Picea rubens* as to *Pinus sylvestris.* A rather significant fact is reported, in that the maximum average tracheid length occurs higher from the ground in annual rings nearer the bark. This is related to, if not due to, the fact that each successive annual increment is larger, extending farther from the ground.

In this work the authors rather forcibly emphasize the fact that to utilize the dimensions of the xylem elements in the classification and identification of the secondary wood of living and fossil plants the averages must be obtained from a large amount of mature material grown on practically all sites common to the species being studied. Generally speaking, averages of this character are of little material value to the dendrologist, being only of practical use to the manufacturer of wood pulp.

CLARENCE F. KORSTIAN.

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THE CYPRESS AND JUNIPER TREES OF THE ROCKY MOUNTAIN REGION[1]

The cypress and juniper trees of the Rocky Mountain region (in the broadest sense) form the subject-matter of a recent bulletin of the Department of Agriculture. The author, Mr. George B. Sudworth, has handled this small group of species in much the same manner employed in his "Forest Trees of the Pacific Slope," bringing together for each tree a body of information that it is impossible to secure in any other collected form. Two cypresses and eleven junipers are described with a fullness which makes their identification an easy matter. The climatic and habital requirements of each species and their manner of seeding and growth are also discussed.

The Arizona cypress is a tree which rarely forms extensive stands, and the recently segregated smooth cypress is of still less frequent occurrence. The junipers are widely distributed throughout the Rocky Mountain re-

[1] Bulletin No. 207, U. S. Dept. of Agriculture, by Geo. B. Sudworth.

gion in the woodland type of forest, and at least seven of them are trees which have some local commercial importance. In most localities where juniper occurs a single species is found to be predominant, and there are few portions of the western United States in which more than two members of this genus grow in close proximity. The statements regarding the longevity of the junipers indicate that they attain great age and grow at a very slow rate, an increase of one inch in diameter requiring 30 to 35 years in *Juniperus monosperma,* about 25 years in *J. utahensis,* and about 14 years in *J. pachyphlœa.* Such low rates of increment occurring in trees that characteristically grow in very open stands would indicate that only a slight utilization can be made of the juniper woodlands.

The identification of the junipers will be greatly aided by the excellent illustrations of the details of foliage and fruit which accompany this bulletin. The plates showing the trees themselves are of a relatively low order of merit. The detailed distributional data have been shown by maps, rather than by actual lists of occurrences, such as were employed in trees of the Pacific slope. This is distinctly a backward step from the standpoint of the man who wishes to make use of these data *in toto,* as well as that of the man who wishes to find out whether a particular tree occurs in a given range of hills or mountains. The maps are highly detailed, but on a very small scale. They show the general distribution of each species at a glance, but it is difficult to use them without possessing a very intimate knowledge of geography and without knowing on which of several commonly used topographic base maps the distribution has been laid down. An outline map of the whole or else of the western half of North America has been used for plotting each species, even if it happens to cover a relatively small area. The selection of a suitable base map for each species, or at least the use of a small series of maps on a larger scale, would greatly enhance the utility of this feature of the bulletin.

The possession of a complete series of bulletins of this type, covering all trees of the Rocky Mountain region, would be of the greatest usefulness to foresters and botanists alike, and it is to be hoped that the treatment of other groups will follow at early dates.

Forrest Shreve.

Desert Laboratory, Tucson, Ariz.

SOCIETY AFFAIRS

The program of meetings tentatively arranged for the season of 1915-1916 is given below. All the meetings except that in San Francisco will be held in Washington, and special announcement regarding the time and place of each, together with any change of program, will be made by postal card.

October 18.—Meeting at Panama-Pacific International Exposition, San Francisco, Cal., with sessions in the morning, afternoon, and evening. To be held in co-operation with the Western Forestry and Conservation Association, the American Forestry Association, and the Pacific Logging Congress, whose respective meetings occur on October 19, October 20, and October 21.

October 28.—The Public Land Policy of the United States. *H. S. Graves.*

November 18.—The Advance in Forest Utilization.

Utilization of Waste by Chemical Means. *H. F. Weiss.*

Service Requirements in Modern Uses of Timber. *E. A. Sterling.*

Practical Experience in Forest Utilization. *C. L. Harrison,* of Himmelberger-Harrison Lumber Company, Cape Girardeau, Mo.

December 16.—The Utilization of Tropical Forests. *Major Geo. P. Ahern.*

January 13.—A Silvicultural System for Longleaf Pine. *I. F. Eldredge.*

The Trend Towards Improvements in Turpentining Longleaf Pine. *H. S. Betts.*

January 22.—Annual Meeting. Devoted to business and the presentation of professional papers. Sessions in the morning and afternoon.

February 10.—Problems Confronting the Lumber Industry.

What the Lumbermen are Doing to Help Themselves. *R. S. Kellogg.*

The Need for Co-operation Among Lumbermen. *R. H. Downman,* President, National Lumber Manufacturers' Association.

———. *Austin Cary.*

The Need for Larger Units of Control in the Lumber Industry. *E. B. Hazen,* General Manager, Bridal Veil Lumbering Company, Portland, Oregon.

MARCH 9.—Forestry in Our National Economy. *Geo. H. Maxwell.*

APRIL 6.—Results of Some Investigations in Plantations and Natural Reproduction in the New England White Pine Region. *E. E. Carter.*

MAY 4.—The Use of Public Forests for Recreation.

The New York State Forests. *Geo. D. Pratt,* Conservation Commissioner, N. Y.

National, State, and Municipal Forests in New England. *Allen Chamberlain,* Boston, Mass.

Southern Appalachian National Forests. *J. S. Holmes.*

The Western National Forests. *E. A. Sherman.*

MAY 25.—The Forests of the World. *R. Zon.*

Several matters came up for a vote before the Society during the summer, with the following results:

1. Lengthening the term of members of the Executive Committee to five years. This was carried.

2. An increase in dues from $3 to $5 per annum. This was lost by a very small margin.

3. The adoption of a pin or other insignia for the Society. This was carried.

4. A provision prescribing a penalty for delinquency in dues. This was carried.

The President has designated Messrs. Pettis, Moon, and Chapman as the committee to select an emblem for the Society. All members are requested to send their suggestions regarding the emblem to Mr. C. R. Pettis, State Forester, Albany, N. Y.

The Executive Committee voted unanimously for the establishment of a local section of the Society at Albuquerque, New Mexico. The temporary chairman of the local section has been informed of the action taken by the committee. The present plan is to hold a meeting in Albuquerque about the middle of December for the purpose of electing officers and adopting by-laws.

The chairman of the Executive Committee has appointed Mr. J. Girvin Peters, chairman; Walter Mulford, and H. H. Chapman to act as a nominating committee for all the elective offices of the Society for the coming year.

Dr. W. K. Hatt, C. E. Faxon, Dr. H. S. Bristol, and G. P. Whittlesey, all associate members of the Society, have resigned.

The Society has received an invitation from the Chicago Association of Commerce to hold its next general meeting in Chicago, and has offered to assist in arranging the details incident to the meeting. The invitation will be referred to the Meetings Committee of 1916 for its consideration.

Mr. Charles H. Shinn has made several suggestions which may be of interest to the Society. He believes that a meeting of the Society in a Pacific Coast Forest at some future time would be very appropriate and practicable. He has also suggested, in connection with the recent ballot taken on the adoption of an emblem by the Society, that an appropriate design would be a brown pin showing a pendant cone and pine needles.

The San Francisco meeting of the Society of American Foresters was successful even beyond the hopes of its organizers. The number of members present—thirty-seven—was far more than was expected, and the open meeting, with its maximum attendance of about 105, is believed by those present to have broken all previous records. The coincidence of the meeting with those of the Western Forestry and Conservation Association, the American Forestry Association, and the Pacific Logging Congress, which followed in order on the following days of the week, and the attraction of having the meeting held on the grounds of the Panama Pacific International Exposition, undoubtedly induced many to come who would hardly have felt justified in undertaking a lengthy trip for a single event.

The meeting was held in the House of Hoo-Hoo, thanks to the kindness of its Board of Governors, on October 18. The morning session, commencing shortly after 10 o'clock, was presided over by Mr. F. E. Olmsted. The following program was given:

The American Forester

His Ideals. P. G. Redington, U. S. Forest Service, Northfork, Cal.

His Opportunities. Coert Du Bois, U. S. Forest Service, San Francisco, Cal.

What the Society Has Done and Can Do for Him. D. T. Mason, University of California, Berkeley, Cal.

His Professional Ethics. B. E. Fernow, University of Toronto, Toronto, Ontario.

The Forests of Borneo. F. W. Foxworthy, University of the Philippines, Manila, P. I.

Dr. Fernow was unable to be present, and his paper was read by the Secretary. The attendance was about 90. After the meeting a brief

visit was made to the forestry exhibits of the Argentine Republic and of Japan, where representatives of the nations in charge welcomed the Society and explained the various exhibits. Following this the Society was entertained at luncheon at the Inside Inn by the lumbermen of San Francisco.

The afternoon session was called to order at 2:30 by Professor Walter Mulford, and the following program given. The maximum attendance was 105.

The Lumberman and the Forester

The Forester's Duties Toward Lumbering. G. M. Cornwall, "The Timberman," Portland, Ore.

The Lumberman's Duties Toward Forestry. F. E. Olmsted, Consulting Forester, San Francisco, Cal.

The Place of Logging Engineering in Forestry. J. F. Clark, Consulting Forester, Vancouver, B. C.

A visit was then made to the U. S. Forest Service exhibit and that of the Philippine Islands, followed by an illustrated talk by Mr. A. F. Fischer, Bureau of Forestry, Manila, on "Forests and Forestry in the Philippine Islands."

An informal dinner, attended only by members of the Society, was held at the Inside Inn at 7 p. m., with 35 present. A general discussion of Society matters followed the dinner, Mr. F. A. Silcox, of Missoula, Montana, presiding.

A request had been received from the American Game Protection and Propagation Association for an endorsement of the present Federal Migratory Bird Law. A resolution offered by Mr. Du Bois in support of this law was adopted. Upon the suggestion of Mr. Mulford resolutions were adopted expressing the thanks of those present to the Board of Governors of the House of Hoo-Hoo for their kindness in permitting the morning and afternoon meetings to have been held in that place, and to the lumbermen of San Francisco for their hospitality in entertaining the Society at luncheon, and also for their cordial invitation to attend the banquet to be held the following Wednesday night in honor of the visiting lumbermen. The Secretary was also directed to send a night letter to the Washington members not present, informing them of the success of the meeting and of the regret of those attending at their absence.

As a preliminary to more specific questions the objects of the Society were briefly discussed. It was generally agreed that the phrasing of the Constitution is slightly misleading, since general propaganda work in favor of forestry is at least implied. A resolution was passed that the

word "*Cause* of Forestry" as used in the Constitution should be replaced by the word "*Profession.*"

A thorough discussion followed of the plan which had been advocated by Mr. Mason in his paper of the morning session of a dual form of membership. The plan advanced provided for the election of Senior Members or of Fellows who should be men of special distinction, while the present Society membership should constitute a Junior or Active Membership. Very thorough discussion brought out the fact that the meeting was almost unanimously in favor of some form of dual membership, and the argument seemed to be chiefly on the point of whether the standards of Junior Membership should be more lenient than the present standards of the Society. The general consensus of opinion was expressed by the following resolution, proposed by Mr. Du Bois, and adopted with but one or two dissenting votes: "That the qualifications for membership remain as at present, with more effective machinery, to be determined by the Executive Committee, for determining achievement or attainment in professional work. That a limited number of persons of distinct achievement be selected each year by the Society at large as Fellows of the Society."

A discussion followed of the necessity of free speech, not only in Society meetings, but in the Proceedings of the Society. A number present expressed themselves as feeling that the censorship exercised by the Forest Service over the publications of its members was unfortunate. A resolution proposed by Mr. Olmsted was adopted, with but one or two dissenting votes, as follows: "That a more liberal policy of free speech in the Society and in its magazine is desirable."

The next question raised was that of the proposed merging of the Proceedings of the Society of American Foresters and the Forestry Quarterly. All present seemed heartily in favor of such a union, and the following resolution, proposed by Mr. Sterling, was adopted: "That the Society of American Foresters will welcome the plan for combining the Forestry Quarterly with the Proceedings of the Society of American Foresters under an arrangement entirely satisfactory to Dr. Fernow, and in keeping with his desires and policies for the maintenance of a technical journal of forestry, and would appreciate suggestions from Dr. Fernow to this end."

A resolution was offered, and after discussion adopted, that "The meeting is in favor of having a paid secretary as the executive of the Society whenever such action shall prove financially possible."

The papers delivered at the San Francisco meeting will appear in subsequent issues of the Proceedings.

Proceedings Wanted

The Society is entirely out of the following issues of the Proceedings: Vol. I, No. 1; Vol. VII, No. 1; Vol. VIII, No. 3; Vol. IX, Nos. 2 and 3. Since there are frequent calls for these back numbers, the Society is anxious to secure copies of them. Any one, therefore, having extra copies of these numbers will do a favor to the Society by communicating with the Secretary, Society of American Foresters, Atlantic Building, Washington, D. C.

The Library of the Department of Agriculture, University of Minnesota, University Farm, St. Paul, Minn., is anxious to obtain a copy of Vol. VIII, No. 3. Any one having an extra copy of this number may dispose of it by addressing the above department.

INDEX TO THE PROCEEDINGS OF THE SOCIETY OF AMERICAN FORESTERS, VOLS. 1–10

FOREST DESCRIPTION

FOREST BOTANY

SILVICS

ECOLOGY

FOREST INFLUENCES

SILVICULTURE

FORESTATION

MANAGEMENT

ORGANIZATION AND REGULATION

PROTECTION

ENGINEERING

UTILIZATION

WOOD TECHNOLOGY

GRAZING

PUBLIC LANDS

REVIEWS

SOCIETY AFFAIRS